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CONTENTS FOR JULY 1942

Vol. 23, No. 7

EDITORIAL

If Rationing Must Come

IN WORDS which probably were as instinctively accurate as they were informal, an astute observer of the Washington scene remarked that some of the people there were "determined to have rationing" in realms including farm equipment. Relevant thereto are remarks by other speakers and discussers at the same and other times during the recent annual meeting of the American Society of Agricultural Engineers in Milwaukee.

In the comprehensive and carefully stated communication from the assistant secretary of the British ministry of agriculture, sent because he was unable to be present in person, it was brought out that allocation and actual placement of tractors and other farm machinery were handled by committees of farmers in the immediate areas, not by remote control from London. This wisdom of using the experience and judgment of men with full local knowledge was singled out for emphatic approval by several of our engineers.

Both in this and other connections the point was made that the men best qualified to know which farmers can make available machinery most productive are the farm equipment dealers. Many such dealers have indexes of every farmer in their territories, inventories of each farmer's equipment, and a personal familiarity with the farmer's efficiency as a producer. President Geo. W. Kable summed up the sentiment by saying that it would be poor engineering to discard this professional proficiency and put the placement of machines into the control of hastily recruited amateurs, however lofty might be their motivation.

Another engineer, recognized for years as an authority on farm machinery and speaking with the added perspective of experience on a rationing board, endorsed the dealer as best qualified to make the best of rationing. He made the further point that any attempt to ration repairs would be ridiculous. Weeds and weather simply won't await the unwinding of red tape.

Looking Backward Won't Win

EAVESDROPPING at the recent A.S.A.E. annual meeting reminded us of the saying that a historian can look back, an economist can look around, but that it takes an engineer to look ahead. An example was the effort to evaluate the need for tractors by the ratio of tractor demand to horse disappearance. That is too much like planning a tank program on the basis of bayonet disappearance.

Similar is the assumption that the need for farm machinery in general can be appraised by looking at the average volume of sales for a decade or a generation back. Since the farm equipment sales curve, followed backward, approaches zero as a limit, the need for new machines can be argued down to any desired level by the simple expedient of embracing enough years in the average. As engineers we know that the main value of a past sales curve is to find a formula expressing the rate of change in slope of that curve so that we can project it into the future.

During the informal discussion of scheduled papers and addresses, several engineers of experience and vision directed attention to the danger of assuming a short war and adopting a policy of trying to see it through with little or no replacement of farm machinery plant. As a way to mitigate postwar problems of business and employment, such an accrued deficit would be a splendid thing, at least in theory. It would be safer to confine the theory to things less vital than the means of food production.

If the military men who plan the production of munitions are right in preparing for a long war as the only safe and sure policy, so must a similar policy be followed for the production of food without which all the munitions will be worthless. We dare not risk obsolescence and deterioration such as made Italian aircraft well-nigh impotent when opposed to new, modern machines.

Milk from Marginal Mines

DISCUSSION by both farm structures and rural electric engineers at the A.S.A.E. annual meeting just held at Milwaukee, indicates that copper is just about the most critical material in the improvement and equipment of farm buildings for increased production of dairy and poultry products. Release of copper wire for hooking up milking machines, coolers, electric brooders, etc., reveals the value of these items in the food program. Severity with which applications for such uses are scrutinized emphasizes the scarcity of copper.

Persons who profess familiarity with our copper resources, claim we could have plenty of copper by allowing prices which would permit operation of the higher cost sources of copper. In an open and competitive market, this would mean higher prices of all copper, for both military and civil uses. But in a time when economics has been superseded by edicts it should be possible to open high-cost mines and earmark their output for high-value civilian purposes, leaving the low-cost copper for national needs.

So segregated, the high-cost copper would have but little direct inflationary influence. By absorbing some of the alleged excess of purchasing power, it would do a bit to resist the inflationary effect of such excess. Since farmstead hookups usually call for but small amounts of copper, an abnormal cost would not be prohibitive for installations which are strategic in food-producing capacity. Or if the principle of subsidy to stimulate production under a ceiling, as demanded in some quarters, is to be adopted, it may be that the place to try it is with copper.

Let Land Not Be Lost

ONE OF the sharpest, albeit briefest, clashes of the recent A.S.A.E. annual meeting had to do with soil saving. One speaker suggested that we should keep production of food high, labor and machinery requirements low, even if we have to let some soil wash away during the war emergency.

Instant objections was interposed. While many projects for terracing, dam building, etc., may properly be suspended, there is no need for a stampede to the misuse of land which occurred during the last war, and which accentuated erosion by wind and water, not to mention the aftermath of social and economic problems of submarginal farms. In general, production needs can be met on lands and by methods suited to growing the several crops in good conformity to soil-conserving principles, if labor, power, and machinery be concentrated in the right places.

AGRICULTURAL ENGINEERING

VOL. 23 JULY 1942 NO. 7

Engineers in War and Peace

By George W. Kable
FELLOW A.S.A.E.

OUR GROUP of engineers has been rendering real service in this war. Even before Pearl Harbor we were training many men for war industries. We have conducted repair schools and clinics for keeping farm equipment in efficient use, and we have aided in the accumulation of large quantities of scrap materials from farms for war industries. Six of our members are serving with the War Production Board as chiefs of sections, advisory members, or consultants. Many members are in the military service.

Right now the one job of the nation is to win the war. Our part in winning is two-fold, namely, that as citizens in giving moral and financial support and service in the armed forces, and as professional engineers in serving agriculture. It is up to us to see that the engineering end of agricultural production keeps up with the tempo of war. It means quick adjustments to meet changing demands. There must be no monkey wrenches in the machinery.

We are meeting at a time when transportation is at a premium. Our program has been rebuilt around a technique of war activities. This should not be a sit-and-listen convention. We have serious work to do, or we should not be here. Let us abandon any convention-as-usual attitude and tackle our problems as men with a job to do. If anything is wrong with methods in vogue, we should criticize them, not just to criticize, but to open the door for constructive action which will improve the methods. We need courage to do our part well and to speak constructively and forcefully enough to get action where action is needed.

Let no man go away from this meeting without contributing something, or carrying with him information, ideas, or inspiration which will make his coming a good investment for the nation.

While our immediate attention and our program is directed toward war, I wish to talk to you about a different matter which also calls for clear thinking and courage. It is about the national structure we will have to live in after the war.

The reason I speak to you about this is because I believe that engineers can and should do something about it. As a class we do not usually concern ourselves greatly with problems of government. Conditions are different today.

Address of the President of the American Society of Agricultural Engineers before the 35th annual meeting of the Society at Milwaukee, Wisconsin, June 30, 1942. Mr. Kable is editor of the magazine, Electricity on the Farm.

GEORGE W. KABLE
President, A.S.A.E., 1941-42

We have been undergoing some great and rapid changes, and there is every prospect that we will emerge from this war with a very different national government than we have had in the past. It may make more difference to us as engineers than any engineering code of ethics or machine design to which we devote time and study.

Another reason why I think that engineers should take new interest in government now is that we have been trained to work from fundamentals. We build foundations first. Our completed machines and structures may be complex, but they are made of simple parts, and we always check back to be sure they are basically sound and strong.

Our government today is an immense and complex structure. It started with a reasonably simple and solid foundation. The superstructure has now grown and spread, until the foundation is becoming obscured. No government can be perfect; it should not be static; but there are certain fundamental principles of freedom and liberty in our government which make us love this country and be willing to fight for it. Let's keep it free.

Last February the Normandie, a 60 million dollar ship lay at her pier in New York harbor. She was being feverishly refitted for war service. There were hundreds of workmen on board. Many officers of high and low rank from several branches of the government service were at hand. Everyone's thoughts were on fast preparation for war service. Then someone struck a spark and in a few hours the Normandie, gutted by fire, with a superstructure squirted full of sea water, lay on her side in the mud. It will take months to right her, and she will probably never again be as good a ship as she was. The New York Herald-Tribune in commenting on the report of the congressional investigating committee said: "Nobody was in charge, nobody was really prepared for emergency, nobody was thinking — and there was apparently no one with sufficient energy to insist upon correcting a condition which had been noted 'time and again'. The report is a shocking one."

The capsizing of the Normandie was a disaster which forethought and simple engineering might have prevented. There will be workmen about with evil sparks when the war is over. We do not want a Normandie "ship of state" after this war.

Most of us believe in organization of labor for mutual cooperation. We strongly favor a high standard of living and good working conditions for the working man. But when men are forced to join unions by intimidation, being

beaten into submission or having their families threatened or property destroyed; when a union's main purpose is to grab without giving in return, and to assume dictatorial control of large masses of men; when men must pay large sums to a racketeer for the privilege of working in a war plant, we have forgotten the meaning of *democracy*. Labor racketeering is the nearest approach we have to Hitlerism in this country. Unionism is now attempting to entwine itself about agriculture.

There are good labor unions in this country. They are organized for the good of members, but with sincere regard for the employer and the public. They place a premium on effort and good craftsmanship; they do not destroy initiative and a willingness to work; they are governed democratically and not by gas-pipe dictators; they give as well as take. We need more such unions. We also need a realization on the part of politicians and the public that there is a distinction between the honest, democratic laboring men in this country and the arrogant, dictatorial political machines set up in the name of labor.

A representative government should represent you and me. Actually, I doubt if many of us would trust our personal or business affairs to the men we elect to office. The chances are great that we do not even know who our representatives are. And yet the government handles our money and banking, regulates our business, tells us whether our little pigs should live or die, attempts to regulate supply and demand, and normally spends more of our income for us than we put into our own savings accounts.

It is difficult for a representative to speak and act with fundamental honesty, even if he has it, because he must "scratch backs" and "roll logs" to get campaign records to keep him in office. He has become part of a system which has grown up as our population has increased and the government has become more complex. We are at fault.

We should vote, but just voting is not the answer. What we really need is training in citizenship, a return to the fundamentals of the town meeting so that we can know what we are voting for and that our vote counts. It can be done. We are training millions of men to fight. I am an auxiliary fireman in my little town on Long Island. I have spent many evenings in training. There are hundreds of thousands of us trained as firemen, air-raid wardens, observers, special policemen, and Red Cross workers. All is voluntary service for war. And the war is being fought to preserve a way of life which we take for granted. Few of us devote as much study to government as we do to learning to handle an incendiary bomb. We need to get back to fundamentals.

Our judicial system was founded on simple justice. It has grown until the foundation stones of justice are scarcely discernible through the superstructure of technicalities, influence, temporary insanity, and legal procedures. The respected attorney, who gets the big fees today, is the one who can free the fellow whom everyone knows to be guilty. Recently the assistant attorney general of the United States completed a four-year prosecution of an anti-trust suit against the Aluminum Company of America. It was a grand case for an attorney. It produced 40,000 pages of testimony, and 10,000 pages of exhibits, and cost about $2,500,000. The government lost on all counts. You and I paid the bill.

There were some mistakes in the simple justice of the old cattle country, but the percentage was probably no greater than at present. The respect for law was greater. While we would not welcome a return to rope-and-tree procedure, some serious interest on the part of laymen on what the judicial system is for, might help us back to simple justice.

In my travels during the past year I have talked with laboring men, manufacturers, executives, farmers, college and government workers. Many of them expressed private opinions that we were drifting into conditions where the freedom of action and of opportunity we have prized was being lost. They were living in fear of being "cracked down on" by the government or by union leaders holding government-made clubs over their heads. That is not a healthy condition.

Some things I have said, I have not enjoyed saying. I have said them because I love my country and because I believe we as engineers can do something about them.

We are a peace loving people, somewhat gullible and slow to anger. When finally kicked in the face by Japan, we have sprung quickly and loyally into action behind our government. Washington is doing the almost inconceivably huge task of quick change-over from peace to war. Yesterday a democracy, we are today under a virtual dictatorship, with our best and most individualistic business men in the front ranks. The fact that we can give up our business, our competitive system, our regular way of life so quickly and unanimously in an emergency is the best demonstration we could have of the effectiveness of the democratic system. A free people with trained initiative can produce materials for war faster and better than a regimented people schooled in obedience to a dictator.

The number of war plants which have sprung up all over this country is amazing. The willingness with which industrialists have buckled into small-salaried war jobs is reassuring. Farm production has increased in spite of a shortage of labor. We are accepting taxes and buying war bonds without flinching.

Our enemies are smart. We supplied them with war materials. Then they struck when we were off guard. To date we have been pretty soundly licked. Let's hope we have learned our lesson. In the end we will win. When the war is over, however, we will still have smart enemies. Will we be caught off guard in our preparation for peace? Even now the enemies of democracy are in training. Ten days ago I listened to a radio debate in which one side argued that because a state-planned economy is now getting results in war production, the dictation of our lives and actions by the state should continue to be the plan of government after the war. It could very easily be if we are off guard. What are we fighting for?

What I have been talking about is not party politics. It is basic government. I recommend that we discuss it in forums. It is an excellent subject for student branch debates. We should handle the subject as engineers, resolving the complex problems into their simple, fundamental parts.

When the war is over, we will have much readjusting to do. There will undoubtedly be a dropping off in demand for some food crops and increasing demand for crops for industry. Labor will return to the farms. Much of it will be trained to operate machines, use welders, work regular hours, and spend war plant wages. We should anticipate and plan for it. In the planning let's not forget that we are citizens as well as engineers. It is not for us to set up a political system or tell the country what to do. What this country does will depend to a large extent on what the individuals in it think and do. We need a lot of straight thinking on simple fundamentals. If enough common people like ourselves think clearly and act courageously in insisting on sound government, we will keep this country free and the land of opportunity we want it to be.

Machinery for Processing Sweet Potatoes for Livestock Feed

By F. A. Kummer
MEMBER A.S.A.E.

THE PRODUCTION of sweet potatoes for livestock feed has recently gained considerable importance and widespread interest among southern farmers. Cotton is the chief cash crop of the South, and the income per farm is about one-third that of the New England and north central states. The most promising way in which the South can increase its farm income is through the production of livestock. This phase of agricultural production is extremely important for the duration of the war to satisfy the urgent food requirements. In addition, however, in the years to follow, great quantities of livestock will be needed to rehabilitate the depleted flocks and herds of the world. In order to conduct a successful livestock program, both protein and carbohydrate feeds must be available in sufficient quantities. While the South has an abundant supply of protein feeds in the form of cottonseed meal and peanut meal, it finds itself in a most unfavorable position with respect to carbohydrate feeds. Corn has long been considered the standard carbohydrate feed, but yields of corn and all other grain crops are extremely low in the southern states. The average yield of corn in Georgia, Florida, and Alabama over the 12-year period 1928-39 was 10.5 bu per acre[1*]. The average yield of corn in Iowa over the same period was 37.8 bu per acre. These differences in the production of standard carbohydrate feeds constitute a severe handicap in the production of livestock which the South must overcome.

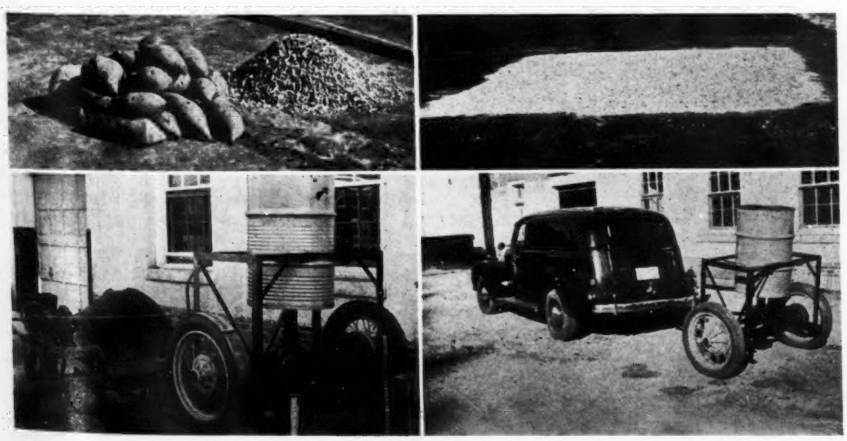
The sweet potato is one southern crop which matches corn in feeding value. It is well adapted to the South, fits well into a livestock program, and gives high yields from an acre. Yields of sweet potatoes reported by the Alabama Agricultural Experiment Station from experiments conducted at different points in Alabama varied from 115 to 507 bu per acre, or an average yield of 296 bu per acre[2,3]. Sweet potatoes offer a variety of products for livestock feeding purposes. The vines provide good grazing and good silage. The protein content of the vines is fairly high, and the leaves are very high in carotene which provides vitamin A. The sweet potato roots may be fed green, converted into silage, or may be dried and thus converted into a concentrated feed. The value of the several forms of feed for different classes of livestock is discussed in other publications of the Alabama station[4,5,6].

In order for sweet potatoes to achieve maximum importance in southern agriculture, they must furnish a carbohydrate concentrate. In the dried form sweet potatoes furnish a concentrate comparable to corn, barley, oats, or other grain crops. The dried product will keep indefinitely without spoilage, thus giving a feed throughout the year. The yield of dried sweet potatoes from a given amount of green or cured potatoes depends upon two factors: the degree to which the potatoes are dried, and the percentage of dry matter in the original potato. As a simple rule, it may safely be assumed that three pounds of green potatoes will yield one pound of the dried product which in carbohydrate feed value is equivalent to one pound of corn. It should be considered at this point that the average yield of 296 bu of sweet potatoes reported by the Alabama station would constitute an equivalent feed value of 99 bu of corn per acre.

While commercial dehydration has been carried out successfully on a limited scale, the progress of this method has been relatively slow because of the high cost of equipment. At the close of 1941 there were only two large driers in the South: one at St. Francisville, La.; the other an experimental unit at the Alabama Prison Farm at Atmore. Since that time a smaller and lower priced drying unit has been constructed by the Tennessee Coal and Iron Company, and comparative performance tests will be conducted on this unit during the coming season by the Alabama station.

Article prepared especially for AGRICULTURAL ENGINEERING. (The method described in this paper was developed at the Alabama Agricultural Experiment Station, with the departments of horticulture, animal husbandry, and agricultural engineering cooperating.) Author: Associate professor of agricultural engineering, Alabama Polytechnic Institute.

*Superscript numbers refer to the bibliography appended to this paper.



Upper, left: Sweet potatoes and dried feed equivalent • Upper, right: An experimental drying surface, consisting of soil impregnated with asphalt priming oil • Lower: An experimental machine developed for shredding sweet potatoes for rapid drying—left, the machine mounted for the shredding operation; right, the machine being transported

In order to exploit fully the possibilities of this process, its scope must be extended further in order to reach even the smaller growers of sweet potatoes who intend to process their own carbohydrate feed. To be of widespread use, the method must be simple, the labor provided by the farmers themselves, and the equipment inexpensive. Sun drying on low-cost drying surfaces seems to offer these possibilities. Experiments conducted by the Alabama station on sun drying of sweet potatoes under different conditions of temperature, air movement, and humidity have proved extremely satisfactory. Comparative tests of drying surfaces have been made with various materials, namely, composition roofing, metal roofing, building paper, kraft paper, and soil surfaces impregnated with asphalt priming oil. The most satisfactory materials from the standpoint of cost and suitability were the oiled soil surface, building paper, and kraft paper in the order named.

One of the primary requirements for the development of small-scale drying was simple equipment capable of slicing or shredding sweet potatoes in sufficient quantities to facilitate rapid drying. The product had to be of such quality as to make a suitable product for feeding purposes. Certain basic features, such as low cost of construction, adequate shredding capacity, and mobility to eliminate long hauls, were considered essential. Because of the variability of power available on farms, the machine had to be readily adaptable to different types of power units. With these requirements in mind, an experimental machine was constructed which has given satisfactory results.

A SALVAGED AUTOMOBILE REAR AXLE ASSEMBLY WAS USED FOR THE DRIVING MECHANISM

A salvaged automobile rear axle assembly complete with wheels and driveshaft was used for the driving mechanism. The torque tube and driveshaft were cut off to a desired length, and to the remaining driveshaft an appropriate length of a separate rear axle, having the tapered and threaded end, was attached to the driveshaft. The driveshaft and torque tube were rotated 90 deg so as to operate in an upright position. A straight driveshaft roller bearing and race welded into the top of the torque tube provided perfect alignment for the axle part of the driveshaft. Two pieces of 3-in angle iron were welded to the bottom of the axle housing to support the hopper frame. One axle was cut off 12 in from the differential, and the remaining part of the axle was locked in the housing. By this method it was possible to utilize the opposite wheel as the driving pulley.

The shredding mechanism was made from a steel disk 5/16 in thick and 20 in in diameter. A wheel hub flange was turned to fit into a 1¾-in center hole in the disk and bolted into place. The disk was then attached to the axle part of the driveshaft. Since the tapered end of the axle was designed to fit into the tapered hole of the hub flange, no machining was necessary. The tapered and keyed end of the axle provided an excellent and safe mounting for the disk flange. The shredding knives were beet-type cossette cutters used extensively in the sugar beet industry. These knives were bolted to the disks over three slots which allowed the shredded material to fall below the disk. A 55-gal oil drum was cut into two parts, and both ends were removed. One-half of the drum was mounted on an angle iron frame directly above the cutting disk to serve as a hopper for the sweet potatoes, while the other half was mounted below the disk to prevent scattering of the shredded material.

In order to facilitate transportation of this machine, a threaded stub shaft was welded into the end of the axle housing opposite the driving wheel which held the wheel in position and allowed it to idle on the hub bearing. A simple angle iron hitch, welded to the lower frame made it possible to transport this machine in trailer fashion. The performance and capacity of this machine has been surprisingly satisfactory. Since the driving mechanism consisted of the best materials available for this purpose, the machine could be operated at comparatively high speeds. A power unit of at least 5-hp capacity was needed to operate the machine. The type of power is entirely optional with the operator. A 5-hp electric motor and also a tractor with belt pulley have been used successfully. In some instances it may even be practical to transmit the driving power from the rear wheel of an automobile or truck. During one test run, using tractor power, 80 bu of sweet potatoes were shredded in 15 min, or at the rate of more than 300 bu per hour. This amount of shredded material would produce approximately three tons of dried feed. It is the author's opinion that a machine of this kind can be built in local machine shops for about $75.00 with materials that are even at this time readily available in practically every locality.

EDITOR'S NOTE: Detailed construction plans and additional information may be obtained by writing the Alabama Agricultural Experiment Station, Auburn, Alabama.

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Bale Tie Straightener Designed by California Agricultural Engineers

To the Editor:

IN line with the editorial, entitled "Two Chances for Re-Use," in AGRICULTURAL ENGINEERING for June, I am enclosing Plan C-213, Bale Tie Straightener, which the division of agricultural engineering at the University of California developed last spring when it appeared that there would not be enough bale ties to go around. About twenty of these devices have been made, so far as I know. The demand has been less than we expected, for the reason that enough bale ties are being delivered to take care of immediate needs. However, the situation may be critical next year, and we know now that bale ties can be reclaimed and re-used.

Plan C-213 is in our regular plan service, and can be obtained by writing Agricultural Extension Service, University of California, 108 Giannini Hall, University of California, Berkeley, Calif. The price of the plan, which includes instructions and blueprints, is 26 cents per copy.

J. P. FAIRBANK

Extension agricultural engineer
University of California

Plywood for Grain Bin Construction

By F. C. Fenton

FELLOW A.S.A.E.

AT THE Fort Hays branch of the agricultural experiment station of Kansas State College, the farm storage of wheat has been the subject of investigation for the past fifteen years. The facts assembled by these storage experiments have been very valuable during the present emergency when so much new farm storage is needed. Bins made of steel, wood, and concrete, and underground bins have been tried under various conditions, sizes of bins, methods of ventilation, and with wheats of different moisture content. All of these studies have contributed to the knowledge of how to store wheat on the farm. They have also led to the design of new types of storage bins.

One of the newest types to be added to the experimental setup was a circular all-plywood bin designed by the author, with the advice and assistance of J. D. Long, agricultural engineer of the Douglas Fir Plywood Association. The new bin has some unusual features besides being the first circular all-plywood bin. It is entirely free from vertical framework, thus making full use of the strength qualities of the plywood. It has only three horizontal hoops made by gluing together four 3-in strips of plywood, and these hoops serve more to give shape to the structure than for needed strength.

One-piece Wall. The bin has walls 8 ft high so one panel applied vertically extends the full height. Similarly the bin is 14 ft in diameter, a size which permits triangular roof sections to be cut from standard size plywood 4x8-ft panels with virtually no waste.

The normal strength of plywood (due to the cross-banding of the layers of wood used in making plywood) is utilized in the walls as the plywood sheets are glued and bolted together into a one-piece covering which literally is wrapped around three laminated plywood hoops.

Design of the bin was drawn specifically to provide a simple granary which could be erected on the farm by the farmer and his helper, or prefabricated by the lumber dealer and hauled to the farm. The experiment proved that it can be built by the ordinary handyman and that the design is free from intricate operations.

In constructing such a circular bin, the only operations that might be new to the average farmer is that of gluing the panels together to make the wall and gluing narrow strips together to form the hoops or ribs. This operation necessitated the use of clamps, and demanded reasonable care, but due to the uniform thickness of the plywood and the tendency to bend uniformly, the job was easy to do.

Following are the specifications of this circular, all-plywood granary:

Capacity: 1000 bu.

Size: 8 ft high, 14 ft in diameter.

Foundation: Four 4-in concrete walls, 12 in high and about 3 ft on centers. Decking of 2x10-in planks spaced 3 in apart. (A more simple and inexpensive foundation would serve.)

Floor: Three-eighths-inch, exterior type fir plywood over 2x2-in joists spaced 12 in on centers.

Framework: Three laminated plywood hoops on inside of wall at top, bottom, and midheight. Hoops are 3½ in wide, formed of four thicknesses of ⅜-in exterior plywood glued, clamped, and nailed together.

Wall Covering: Three-eights-inch exterior type fir plywood. Covering applied in one sheet after 4x8-ft plywood panels have been bolted and glued together into a continuous strip to be wrapped around hoops.

Roof: Three-eights-inch exterior type fir plywood over 2x2-in rafters spaced about 2 ft at perimeter and supported at center by a 16-in ring of sheet steel.

Finish: Two coats raw linseed oil and two coats of varnish on walls; two coats oil and two coats aluminum paint on roof.

Perhaps the first question to come to the average person's mind is: "Will this plywood stand weather?" The answer is "Yes," according to the best information available. By using synthetic resin glues a thoroughly weatherproof product has been produced now commonly referred to as exterior-grade plywood. These panels need only the same protection as ordinary wood exposed to the weather when used for farm buildings.

Construction Methods. Atop the foundation decking was set up a simple, crude jig for forming the framing hoops. Blocks made of 2x4's, 10 in long, were set in a circle approximately 2 ft apart to form the jig. The hoops, 3½ in wide and made of four plies of ⅜-in exterior plywood glued and nailed together, were formed inside and against these blocks.

Plywood strips were used for the framing hoops to determine what advantages it might have over solid lumber strips for the same purpose. This material seemed to bend uniformly and was also uniform in thickness. On the whole, it seemed to be easier to handle than the solid lumber.

Gluing together of the thin sheets of course necessitated the use of clamps. These were used to pull the plies together before nailing for a solid bond and especially at each point that ends of the strips are butted. Eight-foot lengths, ripped from a standard plywood panel, were used. Waterproof glue, a white powder cold mixed on the job, was used as the adhesive to hold in addition to the nails.

The roof framework, consisting of 2x2-in rafters spaced approximately two feet apart at the outside perimeter and butting against the top wall hoop, was supported at the center apex by a 16-in diameter ring of 16-gauge sheet steel. The lower edges of the ring were split into

A circular, all-plywood grain bin designed at Kansas State College

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Article prepared especially for AGRICULTURAL ENGINEERING. Author: Professor of agricultural engineering, Kansas State College.

segments, each of which bends outward to support the rafter ends. The ventilator later was placed over this ring.

Quick Erection. Plywood panels were joined into a continuous sheet to form the wall covering. It took just eleven of the panels, nine of them the regular 4-ft width and two panels each 3 ft wide and forming the ends of the sheet. This length sheet leaves an opening of 2 ft for the door. Assembling of the wall was done flat on the ground. The plywood panels were simply butted together; then a 4-in strip of plywood was lapped over each joint as a batten and glued and bolted in place, two rows of bolts 6 in apart doing the work with extra pairs 3 in from top and bottom. The nuts go on inside of the finished bin.

At each end of the wall a double 4-in batten is glued and bolted in place to act as a door frame. After the wall was erected 2x4-in door jambs were glued inside the wall paneling to stiffen the sides of the opening and carry the grain boards. This sheet then is picked up and bent around the light hoops to provide a one-step erection of the entire wall. It takes four men, or preferably six or eight, to handle it with ease. Bolts are used through each batten to attach the wall paneling to the top, center, and bottom hoops.

Next operation is that of putting on the roofing, which was made of plywood. It takes 23 wedge-shaped roof panels each approximately 7 ft 8 in long, 24 in wide at one end and 2 in wide at the point. Four sections can be cut from each 4x8-ft plywood panel with negligible waste. These are nailed and glued in place with the glue serving both to help hold the panels and to seal the joint against rain. About 1½ lb of white lead were used to fill open joints. Ventilator is installed and flashed down over roof.

The door was of the ⅜-in exterior plywood. Five-ply framework for top, bottom, and center of the door was shaped in the same jig set up for making the hoops so that the door had the same curvature as the outside walls.

Strength Characteristics. When plywood panels are joined together and bent to form a circular grain bin, the question arises as to the strength to withstand the pressures and weights of wheat. Plywood is available in different thicknesses, and of course it would be desirable to use the most economical thickness consistent with adequate strength and lasting qualities.

A number of tests were made of the tensile strength of ¼-in and ⅜-in commercial exterior-grade plywood. The test specimens were 3 in wide and 12 in long.

(Continued on page 222)

TABLE 1

Ultimate strength in tension, lb (Average of five tests)

Thickness of plywood, in	Load acting with the grain of face plies	Load acting across the grain of face plies
¼, 3-ply	4850	3240
⅜, 5-ply	6465	5505

Four views of the circular, all-plywood grain bin, designed by F. C. Fenton, in various stages of construction

Dual Motion Development in a Farm Milk Refrigerator

By John E. Nicholas
MEMBER A.S.A.E.

WHEN A 10-gal can of fresh milk is placed in a cooling cabinet, there are three major factors which directly influence its rate of cooling[1], namely, (1) the water-to-milk ratio, (2) the initially available refrigeration stored in the water bath, and (3) whether or not the water bath is in motion. It has been previously reported and again checked experimentally in farm electric milk coolers such as are in common use (Table 1) that between 70 and 80 per cent of the heat of the milk is transferred to the water bath in the first hour depending upon the conditions employed in cooling it. If the initially available refrigeration is small, the water bath temperature will rise considerably in the first 15 min, defeating the purpose of obtaining rapid cooling in the first hour. It is, therefore, essential to provide a large amount of initially available refrigeration, either in the form of a larger water-to-milk ratio or some ice on coils if the water-to-milk ratio is small. To prevent the growth of bacteria in milk and thereby insure that it will not deteriorate in quality, it should be cooled to an average temperature of below 50 F as quickly as possible after being drawn[2]. Possibly no food product is more subject to spoilage; therefore, any improvement in farm milk refrigerators is of immediate interest to dairymen.

Motion of Milk in Can. In recent tests the effect of simultaneous motion of the milk and the water bath during the entire milk cooling interval on the rate and uniformity of cooling milk in a 10-gal can has been studied. When two fluid media exchange heat, the heat transfer is more rapid when both are in motion. Consequently, a can of warm fresh milk might be expected to cool faster and perhaps more uniformly if placed in a milk cooler which has a large amount of initially available refrigeration and which provides motion to the milk in the can as well as of the water, than if these features are not provided.

Experimental Procedure and Results. A recently developed milk cooler provides simultaneous motion to the milk can which in turn gives motion to the water bath and to the milk within the can. This method of cooling is a departure from prevailing practice in that the milk which is giving up the heat and the water bath which is absorbing the heat, are both in motion. This system of cooling may be referred to as dual motion. It is intended to provide more uniform, though not necessarily more rapid, cooling. A series of different duplicated tests was made with such a cooler with varying water-to-milk ratios to determine its possible advantages and to test its limitations. The milk temperatures were measured by sets of ten thermocouples spaced 2 in apart, which were located vertically in the centers of the cans. Water bath temperatures were obtained by thermocouples similarly arranged but located in the water baths half way between the cans. All data quoted, considered significant but not easily deciphered from the curves, are given in Tables 1 and 2 for convenience of study and analysis.

In the first tests, the cooling load consisted of three 10-gal cans of water at a temperature of 91.7 F and one 10-gal can of milk averaging 90 F. The initial water bath temperature was 40.1 F at the time of loading with no ice on coils, and the water-to-milk ratio, R, was only 1.7. The cabinet was therefore loaded to its full "can-holding" capacity, probably overloading the condensing unit. This method of loading provided the equivalent of small initial available refrigeration which might nullify any advantage of dual motion in the more rapid transfer of heat from the warm milk and which might also allow the temperature of the water bath to rise rapidly. The results of such a test are shown in Fig. 1 in which the water bath rose to 53.9 F in the first half-hour with the top and bottom of the milk at

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[1]Bulletin 375 of the Pennsylvania Agricultural Experiment Station.

[2]Bulletin 404 of the Pennsylvania Agricultural Experiment Station.

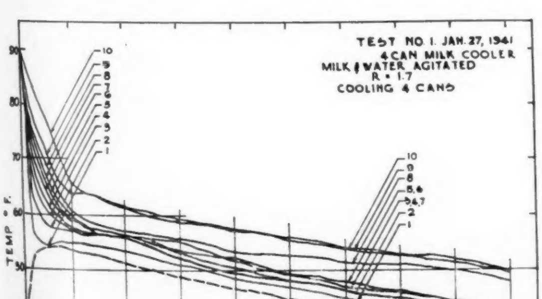


Fig. 1 The temperature gradient in a 10-gal can of fresh milk during a cooling process with the milk can and water bath in motion with the water bath at the initial temperature of 40.1 F, a small water-to-milk ratio, R, equals 1.7. Test 1, Tables 1 and 2

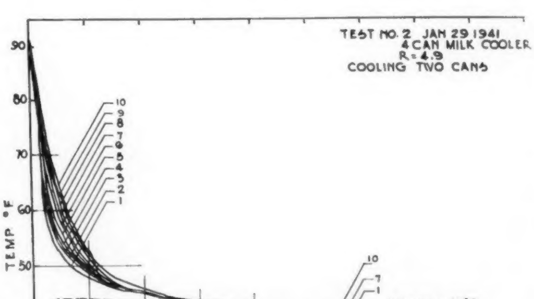


Fig. 2 The temperature gradient in a 10-gal can of fresh milk during a cooling process with dual motion. Initial water bath temperature 37.5 F, and water-to-milk ratio, R, 4.9. The most uniform cooling of the series. Test 2, Tables 1 and 2

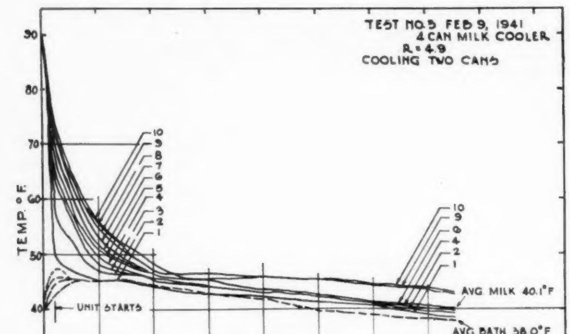


Fig. 3 The temperature gradient in a 10-gal can of fresh milk during a cooling process with the milk can and water bath in motion; water-to-milk ratio, R, equal to 4.9. A delay in dual motion was 15 min. Test 3, Tables 1 and 2

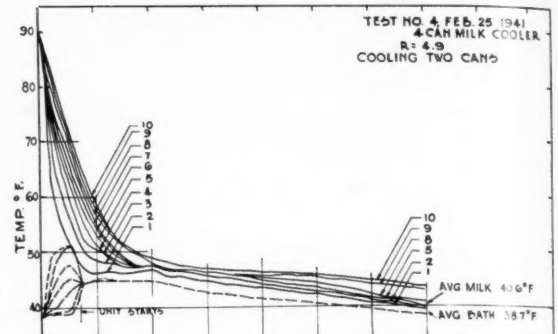


Fig. 4 The temperature gradient in a 10-gal can of fresh milk during a cooling process, with the dual motion delayed 45 min after loading. Water-to-milk ratio, R, is equal to 4.9. Test 4, Tables 1 and 2

77.7 and 54.5 F. The rate of cooling of the milk after the first hour depended on the capacity of the unit. The top and bottom of the milk cooled to 65.9 and 55.0 F, a differential of 10.9 deg (Table 2, test 1), and the water bath was 53.5 F at this interval. An approximate 9.1-deg difference in temperature between top and bottom of milk was later established which continued for eight more hours.

After the first hour of cooling, separation occurred forming a cream layer. After the cream layer formed, its rate of cooling was slower than the rest of the milk. At the end of the ninth hour, the top 4 in of the milk (the probable depth of the cream layer) were approximately at an average temperature of 49 F. The rest of the milk in the can was nearly at an average temperature of 42 F, or a 7-deg differential at this interval. The small water-to-milk ratio and relative high initial bath temperature overloaded the cooling capacity of the unit and the milk cooled neither very rapidly nor uniformly because it required 9 hr to bring the top of the milk to 50 F.

Effect of a Higher Water-to-Milk Ratio. When the water-to-milk ratio was raised to 4.9, the effect of dual motion (water bath and milk in can) was striking, as shown in Fig. 2. The initial average temperatures of the warm milk and the water bath were 91 and 37.5 F, with some ice on the coils. At the end of the first half-hour, the bath temperature reached a maximum of 44 F. The bottom of the milk cooled to 47.9 F and the top to 52.6 F in the first hour, a differential of 4.7 deg. In the next half-hour, the bottom of the milk cooled to 45.7 F and the top to 46.1 F, while the layer, 2 in below the top, as indicated by couple 9, was 47.6 F. The maximum difference between the coldest and warmest parts of the can was but 1.9 deg, and the difference in temperature between the bottom and top of the milk was 0.4 F, indicating remarkably uniform cooling. This small temperature difference between top and bottom was maintained throughout the cooling period. At the end of 6 hr of cooling, there was only 1 deg difference between the top and bottom of the milk. The effect of double motion is a more uniform cooling of the milk after the first $1\frac{1}{4}$ hr. The temperature of the top layer of the milk, shown by couple 10, dropped below the temperatures of the lower layers after the first hour, but there was no experimental evidence to indicate turbulence of such a nature as to cause mixing of the cream layer with the main body of the milk.

Effect of Delayed Dual Motion During Cooling Process. The importance of prompt cooling of the milk soon after it is drawn has been emphasized. Any delay in the promptness of cooling or in the agitation during the cooling may have detrimental effect and might cause bacteriological developments. To study the effect of delayed agitation on the cooling of milk as determined by its temperature gradient, several experimental tests were made with different time intervals of delay.

Fig. 3 shows the rate of cooling of fresh milk and its temperature gradient when the dual motion was delayed for about 15 min after placing the can in the cabinet. Water-to-milk ratio was 4.9 as in preceding tests. The initial average temperatures of warm milk and water bath were 90.2 and 39.5 F, respectively. On absorbing part of the heat of the milk the water bath began to stratify soon after loading, the top reaching a maximum of 47.6 F and the bottom 43.1 F, resulting in a 4.5-deg water bath temperature differential at the end of the first 15 min of cooling. The bottom and top milk temperatures at this interval were

TABLE 1. PER CENT OF HEAT REMOVED FROM CAN OF MILK AT END OF FIRST HOUR
(Based on 6-hr run and total time of test)

Test No.	Duration of test, hr	Water-to-milk ratio	Average temperature of milk, deg F: Start	1 hr	6 hr	End of test	Degrees milk cooled in, deg F: 1 hr	6 hr	Duration of test	Per cent of heat removed at end of first hour based on: 6-hr test	Total time of test
1	19½	1.7	90.0	59.5	48.5	37.9	30.5	41.5	52.1	73.5	58.5
2	6	4.9	91.0	50.0	40.0	40.0	41.0	51.0	51.0	80.4	80.4
3	7½	4.9	90.2	51.2	41.6	40.1	39.0	48.6	50.1	80.3	78.0
4	7¼	4.9	90.0	53.4	42.3	40.6	36.6	47.7	49.4	76.8	74.3
5	8	4.9	93.0	49.9	39.4	37.7	43.1	53.6	55.3	80.3	78.0
6	23	10.8	91.0	46.0	36.3	34.0	45.0	54.7	57.0	82.2	79.0

TABLE 2. TEMPERATURE DIFFERENTIAL BETWEEN TOP AND BOTTOM OF MILK IN CAN AT END OF FIRST, SIXTH, AND FINAL TEST HOURS

Test No.	Temperature of Milk, Deg F: End of first hour: Top	Bottom	ΔT	End of six hours: Top	Bottom	ΔT	End of test: Top	Bottom	ΔT	Temperature of Bath (Ave), deg F: Start of test	End of 1st hr	End of 6 hr	End of test
1	65.9	55.0	10.9	53.8	45.1	8.7	42.4	36.6	5.8	40.1	53.5	43.3	37.2
2	52.6	47.9	4.7	40.3	39.3	1.0	40.3	39.3	1.0	37.5	44.0	39.0	39.0
3	55.7	45.3	10.4	44.5	40.4	4.1	43.1	38.2	4.9	39.5	45.6	39.1	38.0
4	58.8	46.1	12.7	44.9	40.6	4.3	43.9	39.5	4.4	38.4	45.3	39.5	38.7
5	53.2	46.5	6.7	39.2	39.0	0.2	37.7	37.4	0.3	36.0	43.0	37.7	36.1
6	*47.1	39.3	7.8	*39.7	34.7	5.0	*34.7	33.8	0.9	33.4	36.5	34.2	33.8
	**53.8		12.5	**40.2		5.5	**34.1		0.3				

*Thermocouple No. 10
**Thermocouple No. 9

48.5 and 71.3 F, resulting in a 22.8-deg differential. The 15-min delay in agitation of the bath and the motion of the can stratified the water bath and caused a large temperature difference in the milk. An apparent formation of the cream layer became evident after the third hour of cooling are shown by couples 9 and 10, while the main body of the milk continued to cool practically uniformly with less than 2 deg difference between 1 and 8 at the end of 7½ hr.

Fig. 4 shows the results of a test made under practically the same conditions as test 3 but with the delay of dual motion prolonged to ¾ hr. Milk and water bath temperatures at the time of loading were 90 and 38.4 F, respectively. The water bath stratified to higher temperatures than in the preceding tests and a temperature gradient developed in the milk, so that at the time dual motion started the top and bottom temperatures of the milk were at 64.4 and 47 F. The effect of delay of the motion of the two media which exchange heat became more evident after the fourth hour. This delay in the proper cooling procedure, though it gave a 2.2-deg temperature differential between the top and bottom of the milk at the end of the second hour, as shown by couples 1 and 10, was sufficient for a cream layer formation. The cooling of the cream layer was slower, as shown by couples 9 and 10, to the end of the period. The delayed motion promoted a larger temperature gradient at the end of the cooling time than when motion began at the instant the milk is placed in the cabinet as shown in Fig. 2. In the normal operation of any milk cooler, the cycling may vary even under constant loading because of the possible daily variation of the ambient air. The cooling load may therefore be placed in the cabinet at different water bath temperatures varying between the limits maintained by the thermostat.

Test 5, temperature gradients shown in Fig. 5, was a replica of test 2 with the exception of a lower water bath temperature. The initial milk and water bath temperatures at time of loading were 93 and 36 F. At the end of the first hour of cooling the top and bottom temperatures of the milk were 53.2 and 46.5 F, a differential of 6.7 deg with the bottom of the milk 1.4 deg colder than it was in test 2 at this interval. The advantage of a lower initial water bath temperature was to cool the cream layer region (couples 8, 9, and 10) to temperatures slightly lower than the main body of milk between the first and second hour. (See Tables 1 and 2, tests 2 and 5.)

The results of tests shown in Figs. 1 to 5 were made with fresh milk which was placed in cooling cabinets within 15 min after it was drawn.

To obtain some experimental evidence on milk which had been drawn at least two hours before cooling, test 6 was made on an average can of fresh farm milk, which had normally air cooled in the can to an average temperature of 74 F. Two hours elapsed between the time it was drawn and when it again was warmed to an average temperature of 91 F and placed in the milk cooling cabinet.

Fig. 6 gives the results of cooling. The water-to-milk ratio was 10.8 and the initial milk and water bath temperatures were 91 and 33.4 F, respectively, giving a temperature differential of 7.7 deg. Couple 10 (indicated by a dotted curve after the first half-hour) shows a more rapid heat transfer than the lower layer, couple 9. The separation of the cream and the formation of the layer became evident by its slower cooling than the main body of the milk, even before the first hour. After the second hour, the cream layer was noticeably at a different temperature than the rest of the milk. The 2-hr delay interval which elapsed between the time the milk was drawn and the time it was placed in the cabinet probably nullified the uniformity of cooling.

General Discussion. Table 1 summarizes the experimental data for the duration of the tests; water-to-milk ratios used; and average temperatures of the fresh milk at the start of each test. The average values for the first and sixth hour intervals were calculated from the 10 thermocouple readings at the specified intervals and represent very nearly the readings of the fifth thermocouple. The number of degrees the milk cooled in the first hour, six hours, and total time of test is based on the average calculated values indicated above.

The first and sixth hour intervals were chosen arbitrarily for a basis of comparative analysis. Test 2 was terminated at the end of the sixth hour, because the final average temperature of the fresh milk reached 40 F, to which all data on the other tests are referred as a basis.

In test 6 (Table 1) the average milk temperature was 36.3 F at the end of the first six hours and cooled but 1.7 deg additionally in the succeeding 17 hr.

Table 2 gives the temperatures of the milk at the top (couple 10) and bottom (couple 1) of the can at the end of the first and sixth hours of cooling and at end of the test. The values ΔT are calculated values, referred to in the table as "temperature differentials" at the specified intervals. The average water bath temperatures are also given at the specified intervals of testing.

The short delay in dual motion in tests 3 and 4 stratified the water in the baths causing large temperature dif-

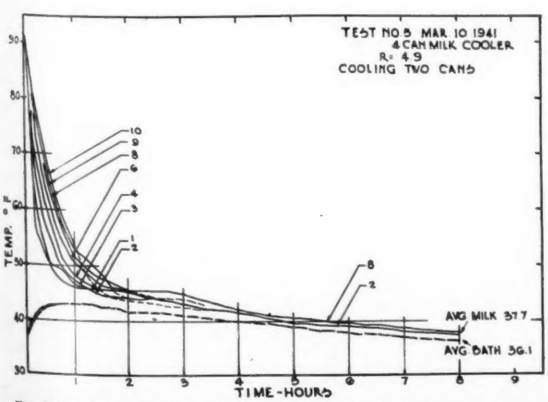


Fig. 5 Temperature gradient in a 10-gal can of fresh milk during a cooling process with dual motion, initial water bath 36 F, water-to-milk ratio, R, equal to 4.9. A duplicate of test 2, but the load was placed to cool during a slightly colder part of the cycle—a normal procedure

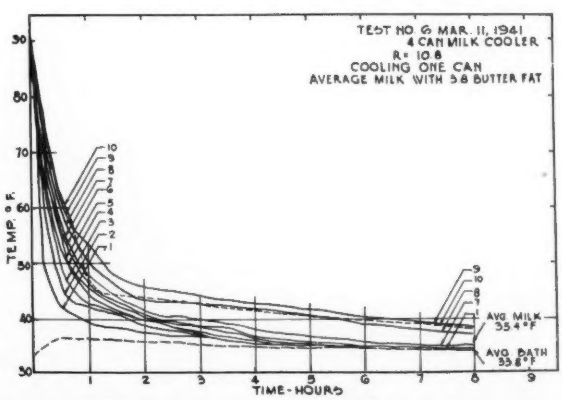


Fig. 6 Temperature gradient in a 10-gal can of fresh milk which has been drawn two hours before cooling. R = 10.8; initial milk and water bath temperatures 91 and 33.4 F; heavy ice bank on coil at start

ferences in the milk and the water bath. Fig. 4 shows the results of a test made under similar conditions as test 3, except that motion of the water bath as well as of the can was delayed ¾ hr. The water bath stratified to a higher temperature than in test 3. The effect of delaying the motion of the media which exchange heat is to delay the cooling of the top strata in milk. In test 4 a temperature difference of only 2.2 deg between the top and bottom of the milk existed at the end of the second hour as shown by couples 1 and 10. The subsequent formation of a cream layer and its slower rate of cooling, shown by couples 9 and 10, becomes again evident at the end of the fourth hour (test 4).

Test 6, Tables 1 and 2, was made on fresh milk which had been drawn and allowed to stand two hours but which was rewarmed to the initial temperature of the other tests before being placed in the cooling cabinet. Whatever separation took place during the two-hour interval apparently prevented the uniform cooling which was obtained in the tests where fresh milk was immediately cooled after drawing. A study of bacterial growth in milk when cooled under the conditions analyzed in this paper is now in progress. Possible effects of the motion of the can on the milk, "rapid" or "slow" creaming or even churning, should be studied. No evidence of any such change in condition was apparent in these studies. There was no experimental evidence in the studies here reported to indicate fat clumping dispersion which is said to cause shallow cream layering.

SUMMARY

1 This paper reports the results of cooling fresh milk (a) when the water bath and the milk can were both in motion at the time of loading, using a small water-to-milk ratio, R, equal to 1.7, Fig. 1, (b) when the water bath and the milk can were both in motion at the time of loading with a larger water-to-milk ratio, R, equal to 4.9, Fig. 2, (c) when the method of cooling was as in (b) except that the motion of the water bath and that of the milk was delayed 15 min, Fig. 3, and (d) when the method of cooling was similar to that of (b) and (c), except that the motion of the water bath and that of the can was delayed ¾ hr, Fig. 4.

2 Results of delay in agitation shown in Fig. 3 indicate that there was a separation of the cream and the formation of a cream layer after the third hour and that its rate of cooling was much slower than that of the remainder of the milk.

3 The effect of a longer delay in agitation as recorded in Fig. 4 had approximately the same effect on the cream layer as a shorter period of delay.

4 Delay in cooling milk for several hours after it is drawn may cause a more complete separation of the cream and the formation of the cream layer and subsequent slower cooling, Fig. 6, test 6, Tables 1 and 2.

5 After the milk has been drawn and its cooling has been delayed several hours, uniform cooling is more difficult to obtain.

6 Test 1 and test 5 are similar except that the initial average bath temperature in test 5 (Tables 1 and 2) was lower and the average initial milk temperature was 2 deg higher.

7 Tables 1 and 2 are included for a clearer analysis of temperature differences and amounts of heat removed from milk.

8 Dual motion provided most uniform cooling when milk was placed to cool soon after it was obtained, under the specified conditions of tests 2 and 5.

Plywood for Grain Bin Construction

(Continued from page 218)

The tensile stress due to wheat pressures on the bottom foot of a 14-ft diameter circular bin 8 ft deep is approximately 1600 lb. The strength of 12 in of 5-ply ⅜-in plywood as it was used in the bin described above would be about 22,000 lb, or would have a factor of safety of about 14. Even the ¼-in plywood has adequate strength to withstand the tensile stresses in moderate size bins due to the pressures of wheat.

The problem is obviously one of joining the plywood together in such a manner as to utilize a fair share of its strength. In order to shed some light on the joint problem, tests were made on ¼-in plywood joints using bolted joints, bolted and glued, nailed and glued, each with lapped joints, and butted joints with splice battens.

TABLE 2. STRENGTH OF PLYWOOD JOINTS

Type of joint, all ¼-in exterior grade plywood	Type of load	Ultimate strength, lb (Ave. of 3 test specimens)	Working load per foot of wall height, lb (Factor of safety, 4)
3 – ¼-in bolts 3 in o.c. 4-in lap joint 6 in wide	Compression parallel to grain of face ply	2100 (700 lb per bolt)	1000
7 – ¼-in bolts 1 in o.c. 4-in lap joint 8 in wide	Compression parallel to grain of face ply	4200 (600 lb per bolt)	1500
Glued and bolted 2 – ¼-in bolts in a 4-in lap joint 4 in wide	Tension parallel to grain of face plies	3435	2800
Glued and bolted 4 – ¼-in bolts in a 4-in lap joint 4 in wide	Tension parallel to grain of face plies	3350	2800
Nailed and glued 9 small nails clinched 4-in lap joint 4 in wide	Tension parallel to grain of face plies	4800	3500
Nailed and glued butt joint with 6-in lap splice plate joint 4 in wide	Tension parallel to grain of face plies	2250	1700
Nailed and glued 9 small nails clinched 4-in lap joint 4 in wide	Tension perpendicular to face plies	2180	1100
Nailed and glued butt joint with 6-in lap splice plate joint 4 in wide	Tension perpendicular to face plies	1320	1000

The results on the strength of joints in plywood were somewhat disappointing in that it was impossible to develop the full strength of the wood in the joints. The strength of the joints was consistently low because the load is not applied in a symmetrical manner on lapped joints or butted joints with a splice plate on one side. This puts more stress on the plies on one side than the other and causes failure at lower loads.

The strength of bolted joints depended upon the number of bolts used and in order to utilize the strength of the plywood a large number of bolts would be required.

Glued and nailed joints seem to be the most promising method of joining plywood for grain bin construction. Due to the regular thickness, excellent joints can be made by clinching small nails by driving them against a steel plate laid under the joint. This would be a quick and easy method of joining plywood together on the job.

A Study of Egg Cooling Methods

By John W. Weaver, Jr., Reece L. Bryant, and Cecil Rogers
MEMBER A.S.A.E.

ABOUT eight hundred million eggs are produced annually on Virginia farms[13]* and three-fourths of these are sold, bringing in a cash income of nearly eleven million dollars. Fifty-two percent of this production occurs during the five months (May, June, July, August, and September) of warm and hot weather when eggs are selling for an average of 3½c less per dozen than during the rest of the year. At the same time the poultryman is feeding young birds which produce almost no income before cold weather. Therefore, the hot weather months are the critical period for the poultryman and any method of increasing income during this time would prove most valuable.

Shrader[11] reports that fully 5 per cent of all eggs produced are lost somewhere between the nest and the table. This is a staggering total when considering that the Food-for-Freedom production goal for 1942 is 4,200,000,000 dozens. This loss, then, runs well over 200,000,000 dozen or more than 50 million dollars.

The Virginia Division of Markets has long recognized the need for widespread marketing facilities for quality eggs and in 1928, in cooperation with the U.S.D.A. Agricultural Marketing Service, launched a federal-state egg grading program[6]. During the first year under this program slightly more than 14 million eggs were graded in an effort to create interest in the production of quality eggs. That this program has proven worth while is indicated by the fact that during the fiscal year 1939-40, more than 71 million eggs were graded, labeled, and marketed through 40 federal-state supervised grading stations within the state. Records from these sales show that, though representative of the best eggs produced at present, there is a difference of 20 per cent in the number of top grade eggs received in hot weather as compared to cool weather receipts.

With the above facts in mind, a cooperative project was initiated to study methods of cooling eggs and the resultant effect on the quality when marketed. (In this paper the term "cooling" refers to the maintenance of air conditions, other than room conditions, around eggs during short holding periods.) At the outset it was decided that cooling eggs on the farm alone could solve only a part of the problem of maintaining quality and that however carefully the quality were preserved on the farm it might be almost immediately lost upon delivery to a market lacking cooling facilities. Consequently the project was outlined to study methods of cooling eggs, both on the farm and at receiving stations.

According to Almquist[1], experimental work has disclosed several facts which show that eggs are not "created equal", or, if they are, they do not long remain so. Initial quality and keeping quality may vary greatly from egg to egg but are found to vary to a relatively small extent in the eggs from the same hen. It appears, also, that even with perfectly consistent grading by candling, or by any other method, eggs originally all of one grade, because of the wide difference in their keeping powers, will be found distributed in part through several lower grades after storage or shipment. It is evident then that frequent gathering and cooling of eggs will not eliminate or correct their inherent initial and keeping qualities. Further, it is plausible to believe that the results of cooling eggs from several flocks of hens would not be identical and that the final quality of eggs, as consumed, could be improved by careful breeding and selection of hens which produce eggs of high initial and keeping quality.

The question then naturally arises as to whether or not the cooling of eggs can possibly assist in profitably maintaining the quality of eggs under present conditions. Montfort[7], Winton[14], and Black[3] state that there is just as much deterioration in three days when eggs are held at 98.6 F as in 23 days when kept at 60.8 F, or in 65 days when the temperature is 44.6 F. While this account shows vividly the effect of air temperature on egg deterioration, it does not consider air moisture or relative humidity which others have found to be an important factor. For instance, Jeffrey and Darago[4] found that interior egg quality, as expressed by height of the thick albumen, was not affected by relative humidity and that decline in interior egg quality was regulated by temperature. At the same time, however, a high relative humidity tended to reduce the rate of evaporation of the egg content and also reduced the incidence of eggs with severely mottled shells. Results from their studies indicated definitely that low relative humidity causes shell mottling.

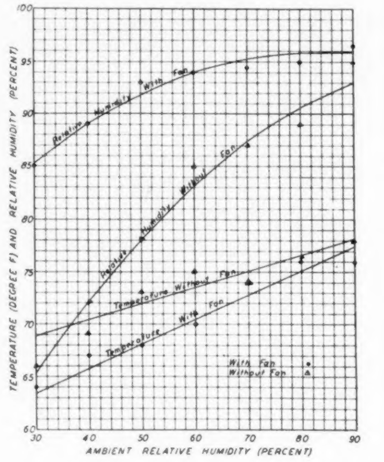
Alp, Ashby, and Card[2] have shown that two shippers using wet burlap curtain coolers similar to those developed in California[9] and Oklahoma[12] increased the number of "extras" in eggs shipped from Illinois to New York by an average of 28 per cent. They warn, however, that trouble from mold may develop if the cooler is used in a room

Fig. 1 The burlap curtain cooler as used for egg cooling tests. Eggs are initially stored on trays to quickly remove animal heat

Paper presented June 23, 1941, at the annual meeting of the American Society of Agricultural Engineers at Knoxville, Tenn. (Revised to date.) A contribution of the Rural Electric Division. Authors: Respectively, associate agricultural engineer, Bureau of Agricultural Chemistry and Engineering, U. S. Department of Agriculture; assistant poultry husbandman, Virginia Agricultural Experiment Station, and senior supervisor, division of markets, Virginia Department of Agriculture.

*Superscript numbers refer to bibliography appended to this paper.

without sufficient ventilation. Thompson and Roberts[12] observed that 96.8 per cent of the eggs stored in a wet burlap cooler and 97.2 per cent of those stored in a mechanical refrigerator graded No. 1 eggs after eight days of storage.



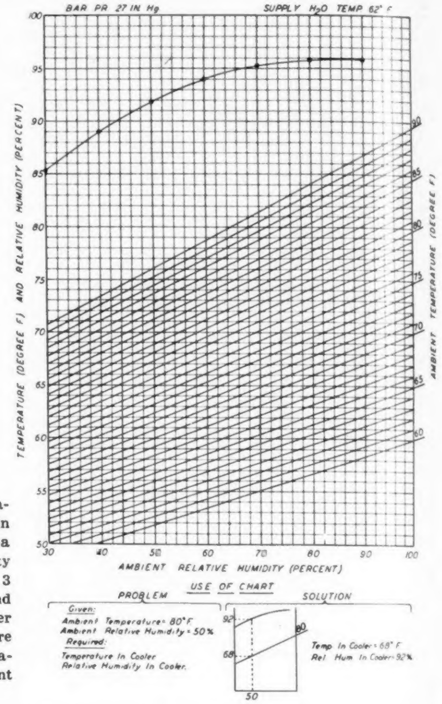


Fig. 2 (Above) Interior temperature and relative humidity maintained by burlap curtain egg cooler when operating with and without a fan in relation to ambient relative humidity when ambient temperature is 80 F • Fig. 3 (Right) Chart showing the temperature and relative humidity the burlap curtain egg cooler will maintain when surrounding temperature varies from 60 to 90 F and surrounding relative humidity varies from 30 to 100 per cent

TESTS OF EVAPORATIVE COOLERS FOR FARM USE

All tests reported in this paper, unless otherwise noted, were conducted during 1940 and 1941 in the rural electrification laboratory of the agricultural engineering department, at Virginia Polytechnic Institute.

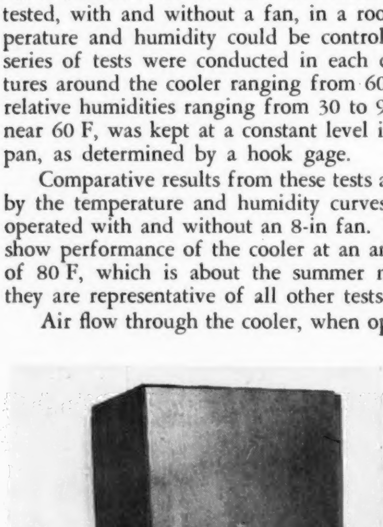
Burlap Curtain Cooler. Since the burlap curtain cooler is of low initial cost and in some cases[12] approaches very closely to the mechanical refrigerator as a device for conserving egg quality, it was given first consideration at the outset of the project. It was thought that a small electric fan might be incorporated into the burlap cooler, to provide a definite movement of air through the wet curtain, improve the performance of the cooler and eliminate the development of molds. Such a cooler was constructed (Fig. 1) and tested, with and without a fan, in a room where the temperature and humidity could be controlled as needed. A series of tests were conducted in each case with temperatures around the cooler ranging from 60 to 90 F and with relative humidities ranging from 30 to 90 per cent. Water, near 60 F, was kept at a constant level in the upper cooler pan, as determined by a hook gage.

Comparative results from these tests are shown in Fig. 2 by the temperature and humidity curves for the cooler as operated with and without an 8-in fan. While these curves show performance of the cooler at an ambient temperature of 80 F, which is about the summer mean for Virginia, they are representative of all other tests.

Air flow through the cooler, when operated without the fan, was so slow that it could not be measured by any of the instruments available. Smoke was used, however, to determine the direction of flow, which was found to be from top to bottom of the cooler. This flow was most rapid when the ambient relative humidity was low and decreased as this humidity increased until at a point of 80 per cent or above there was little or no air flow in either direction. Without a fan on the cooler there was no movement of air directly through the wet curtain at any time.

The bottom of the cooler was made airtight when the fan was used so that all entering air was drawn through the wet curtain and exhausted through the top of the cooler. This air flow was fairly constant under all operating conditions and provided the cooler with about four air changes per minute as determined by a vane anemometer.

Data from these tests have also been condensed into a performance chart (Fig. 3) which shows the temperature and humidity the burlap curtain cooler, with fan, will main-



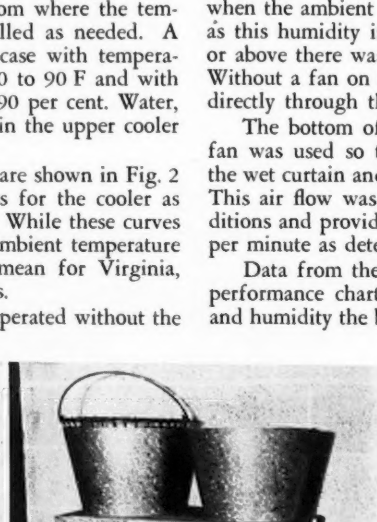
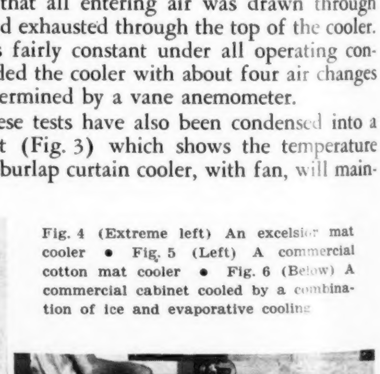


Fig. 4 (Extreme left) An excelsior mat cooler • Fig. 5 (Left) A commercial cotton mat cooler • Fig. 6 (Below) A commercial cabinet cooled by a combination of ice and evaporative cooling



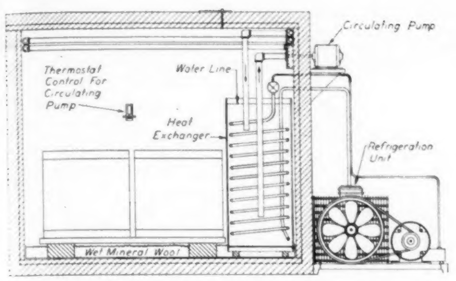


Fig. 7 Diagrammatic sketch of modified coil cooler showing principle employed to obtain a high relative humidity with mechanical refrigeration

tain in operation under varying ambient temperature and relative humidity conditions. While this chart has been prepared for a barometric pressure of 27 in of mercury, it can be used to determine performance at elevations from sea level to 5000 ft without introducing an error of any practical significance. From the chart it may be seen that temperatures maintained in the cooler are dependent upon both ambient temperature and relative humidity, while humidities maintained in the cooler are dependent only upon ambient relative humidity for the range in ambient temperature from 60 to 90 F. This chart can also be used to approximate the performance of the burlap evaporative screen used in egg grading stations to be described later.

Conclusions from the tests outlined above led to the use of the small 8-in fan on the burlap curtain cooler in all subsequent egg cooling tests. Such a cooler can be constructed for about $25, including labor. When eggs are shipped twice each week, this cooler has a weekly capacity of six 30-doz cases, allowing space for cases to be precooled and trays where eggs are initially stored for quick removal of heat. Plans for construction of this cooler are available upon request.

Excelsior Mat Cooler. An excelsior mat cooler (Fig. 4) was constructed according to plans furnished by a well-known manufacturer of electrical poultry equipment. Tests under controlled conditions showed this cooler to be less effective than the burlap curtain cooler. Temperatures ranged from one to four degrees higher and relative humidities from one to 16 per cent lower in the excelsior mat cooler than in the burlap curtain cooler.

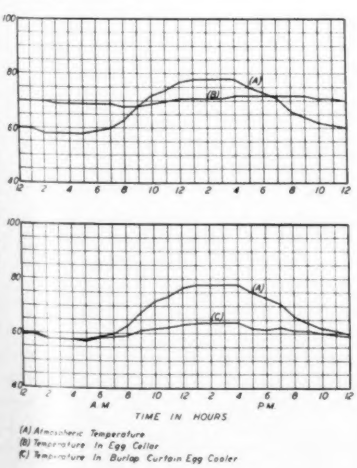
Cotton Mat Cooler. Tests of a commercial cotton mat cooler (Fig. 5) showed it to be even less effective than the excelsior mat cooler, largely because of the fact that air was forced over the mat rather than through it. This cooler is only effective in removing the animal heat from eggs and does not provide storage space for the eggs after the initial cooling period.

Commercial Ice Cooler. A commercial cabinet (Fig. 6) cooled by a combination of ice and evaporative cooling was found to have an inherent high operating cost. During the summers of 1940 and 1941 this cooler consumed an average of 56 lb of ice daily, or 65 lb per case cooled, in maintaining an average temperature of 65 F. At the same time an average relative humidity of 67 per cent was maintained within the cabinet. When eggs are shipped twice each week, this cooler has a weekly capacity of six cases, allowing space for cases to be precooled and for wire baskets where eggs are initially stored.

Experimental Coil Cooler. An experimental cooling cabinet was constructed similar to a wet-storage type milk cooler, having a weekly capacity of six cases and providing trays for initial cooling of eggs. It was made 38 in square and 32 in deep inside, and enclosed a coil made from 60 ft of ½-in copper tubing. The cabinet was insulated with asphalt-impregnated building board, ¾ in thick, and 2 in of mineral wool. This assembly was called the "coil cooler" and was designed as an auxiliary to a large farm refrigerator or milk cooler. For egg cooling tests it was operated in conjunction with a four-can wet-storage milk cooler. A small thermostatically controlled pump was connected to recirculate refrigerated water from the milk cooler through the copper coil in the egg cooler.

To provide higher humidity conditions, a shallow pan was built to cover the entire floor of the cabinet. The bottom of the pan was covered with a 2-in mat of mineral wool and a false slatted floor provided a support for egg cases. The pan was partially filled with 3 gal of water, most of which was taken up in saturating the mineral wool. The humidifying effect of this arrangement was disclosed from egg cooling tests through a period of one month with the thermostat adjusted to hold a temperature of 58 to 60 F. Throughout this period the relative humidity remained be-

Fig. 8 (Below) Comparison of temperatures in egg cellar and burlap curtain egg cooler with same atmospheric temperature around each • Fig. 9 (Right) Comparison of relative humidities in egg cellar and burlap curtain egg cooler with same atmospheric relative humidity around each



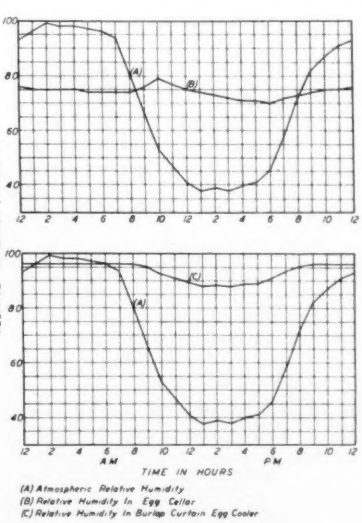
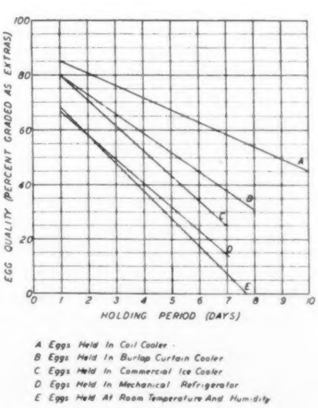


Fig. 11 Effect of duration of holding period on egg quality as related to method of treatment



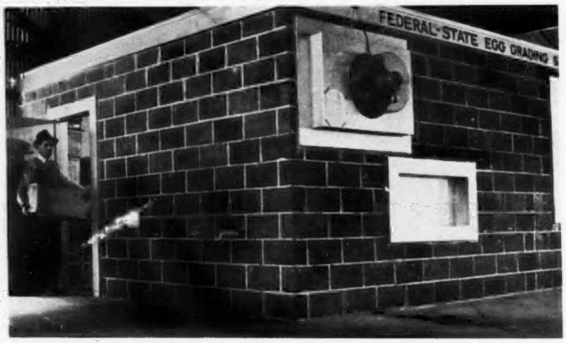


Fig. 10 An egg grading station at Danville, Va., cooled by evaporation when air is forced through a burlap screen into the grading room

tween 70 and 80 per cent regardless of surrounding air conditions. Observations showed that, though water condensed on the cooling coil, it merely collected to later drop into the water pan, providing a continuous cycle of humidification.

Results of egg cooling tests showed that the experimental coil cooler maintained egg quality at a higher level than any of the other coolers tested. Consequently it was decided to employ the same principle in modifying the coil cooler into a self-contained unit capable of maintaining a somewhat lower temperature with the same high humidity. The copper-cooling coil in the original cabinet was replaced by two turns of ¾-in galvanized iron pipe in the upper part of the cabinet (Fig. 7). A ¼-hp mechanical refrigeration unit was connected to a heat exchanger located inside the cabinet. The heat exchanger consisted of an evaporator coil set in a 5-gal ice cream can nearly full of water. The thermostatically controlled pump was connected to recirculate water from the heat exchanger through the two turns of pipe. The refrigeration unit was adjusted to maintain about ¼ in of ice on the evaporator coil.

While no eggs have as yet been graded from this modified cooler, tests have been made with the cooler operating under full-load conditions. When maintaining a temperature of 48 to 50 F, the relative humidity ranged from 70 to 75 per cent in the cooler. During these tests the air temperature around the cooler ranged from 75 to 82 F and the relative humidity from 20 to 45 per cent. The compressor operated from four to six hours daily, and the electricity cost for refrigeration and recirculation of water averaged 7c daily at 3c per kw-hr.

Mechanical Refrigerator. The ordinary mechanical refrigerator was found to have a low operating cost, about 2½c daily, even when maintaining a temperature from 10 to 25 F lower than the other coolers. During these tests the relative humidity in the refrigerator ranged from 48 to 52 per cent.

Egg Cellar. The most universal method of storing eggs on Virginia poultry farms at present employs an egg cellar. The use of cellars in some sections of the state is limited by rock formations close to the soil surface and in other sections by a high water table, making cellar construction costly and uncertain. A typical egg cellar, extending 5 ft below ground, was observed for temperature and relative humidity in comparison with the burlap curtain cooler. From the records, shown graphically in Figs. 8 and 9, it was found that the burlap curtain cooler maintained a temperature about 10 F below and a relative humidity about 15 per cent above those in the egg cellar. It was also observed that a small fan, used to draw air into the cellar at night, might be effective in holding egg quality at a higher level.

TESTS OF COOLERS FOR EGG-GRADING STATIONS

Cold Storage Room. One of the grading stations in Virginia was located at a cold storage plant. The operator reported that the practice of holding eggs for periods of two to four days in a cold storage room at a temperature of about 36 F had been followed at one time. An analysis of egg sales records showed this practice to be uneconomical, and it has been discontinued. This report has been substantiated by egg cooling tests in the laboratory with storage temperature averaging 37 F in a mechanical refrigerator.

Ice Bunker. Prior to 1940 there were two grading stations in Virginia cooled by bunkers of ice similar to the principle used in refrigerated railroad cars. A small fan was installed to blow air through the ice into all parts of the room. This system was found costly to operate. One of these rooms, 8 ft wide, 20 ft long, and 8 ft high, was insulated with 4 in of mineral wool. The operator reported an ice cost of from $25 to $30 monthly when holding the room temperature about 65 F in hot weather.

Excelsior Screen. The ice-cooled room, described above, was converted in 1939 for cooling by the evaporation of water, similar to that developed in California by Perry and Long[8]. An excelsior screen 2½ ft wide, 3 ft long and 2 in thick, was installed in one end of the room. A 12-in exhaust fan was installed in the other end of the room to draw air through the screen and into the room. Water trickling from a perforated pipe above the screen kept the excelsior wet. Waste water was caught and carried off by a short length of eaves trough below the screen.

Tests during the summer of 1940 disclosed that the excelsior screen provided a temperature from 4 to 15 F below and a relative humidity from 35 to 50 per cent higher in the room than outside. The operating cost of the room averaged slightly over $3 per month for electricity and water. The 12-in fan drew 770 cu ft of air per minute through the screen at an average velocity of 102 fpm, providing the room with 0.66 air changes per minute.

Observations made at this time showed that improvements could be made in the construction of such rooms. For instance, when the door to the room was opened there was an inrush of hot air because of the location of the fan. The resistance to air flow through the open door was less than through the wet excelsior screen, and the room was well tempered with hot air from the outside each time the door was opened. This condition was corrected in subsequent installations (Fig. 10) by locating the fan to force air through the screen and into the room.

Burlap Screen. The difficulty of preventing leakage of water from the excelsior screen and the fact that it is impossible to fill the screen uniformly with excelsior and keep it uniformly wet, led to the development of the burlap screen. This screen has been found more effective than the excelsior screen and is simpler to construct, lower in first cost and easier to maintain and renew. It is made by forming a rectangular frame of ½-in pipe with a tee and a union fitted into the lower side. The upper part of the frame is perforated with 1/16-in holes at 2-in intervals. Four layers of medium-weight burlap, two on each side of the frame, are held in place by sewing around the edges. The screen is fastened in place by four conduit clamps and the water supply line connected to the tee. Thus water is carried to the screen by the supporting frame.

The effectiveness of the burlap screen can be approximated by using the chart (Fig. 3) worked out for the burlap curtain egg cooler. Plans are now available showing construction details of the egg grading and cooling room embodying the burlap screen. Tests have shown that for optimum effectiveness rooms of this type should be provided with from one to two air changes per minute. To eliminate draft, uncomfortable to occupants of the room, the velocity of air flow through the screen should not exceed 125 to 175 fpm. The screen should be taken down monthly, or oftener when operated in dusty surroundings, and thoroughly flushed with water under pressure. Partially completed tests indicate that a centrifugal blower will prove more satisfactory than the exhaust fan for forcing air through the screen.

EGG COOLING TESTS

To determine the practical value of cooling equipment, previously described, a series of egg cooling tests were conducted during the summers of 1940 and 1941. Eggs for these tests were obtained from a trap-nested flock of White Leghorn pullets at the Virginia Agricultural Experiment Station. The eggs were gathered twice daily, at 11:00 a.m. and 4:30 p.m., and graded by weight. They were then divided into lots, uniform by weight, averaging about 4 doz eggs. Each lot was numbered and given a predetermined treatment by storing in one of the coolers or at room conditions. New cases, flats, and fillers were used throughout all tests. As a rule, eggs were shipped twice each week from Blacksburg, Va., by railway express to a federal-state supervised grading station in Washington, D. C., a distance of 258 miles. All eggs were candled and graded in Washington by certified graders and a record kept, by lots, of the number of eggs in each grade and the resultant selling price. About 17,000 eggs were handled as described above during the course of the tests.

Cooling Eggs in Farm Coolers. The results from 92 tests in three series of studies of cooling eggs in farm coolers are summarized in Table 1. Observations from these tests have shown conclusively that there is no significant loss in egg weight, either with or without cooling, during short holding periods of four to six days. It is evident then that where eggs are sold semiweekly through a market which considers only quantity, as does the country store, or quantity and weight, as many commission merchants do, there can be no financial gain by cooling eggs.

Where eggs are sold on a graded basis (U.S. Standards of Quality for Individual Eggs, or an adoption thereof), the producer cannot afford to neglect the cooling of eggs by some method. These tests, carefully regulated, have definitely shown that the poultryman can consistently effect a gain in net income of from one to two cents per dozen when eggs are cooled in hot weather by a carefully selected method. This gain can be effected practically independent of fluctuations in egg prices.

Effect of Duration of Holding Period on Egg Quality. A study was made of the records to determine the effect of the length of the holding period on the quality of eggs held in the farm coolers. The results are shown graphically in Fig. 11. These observations were made from records of eggs graded in Blacksburg so that shipping losses were eliminated. Thus it was found that the value of cooling increases as the length of holding period increases. It may be seen that the ordinary mechanical refrigerator is a surprisingly poor piece of equipment for cooling eggs during short holding periods.

Effect of Cooling Prior to Shipment on Quality After Shipment. Most poultrymen in Virginia are within 60

TABLE 1. SUMMARIZATION OF EGG COOLING TESTS IN FARM EGG COOLERS

Date	Number of tests	Number of eggs	Treatment of eggs	Conditions around eggs during treatment: Temperature, deg F	Conditions around eggs during treatment: Relative humidity, per cent	Age of eggs when marketed, days	Eggs graded "extras", per cent	Cooling costs per case, dollars*: Electricity	Ice	Water	Labor	Depreciation	Transportation costs, per case, dollars	Net income per case, dollars	Net gain per case by cooling, dollars	Net monetary gain, per cent**
7/16/40 to 8/22/40	9	1514	Stored at room conditions	77	73	4	30.5						0.60	6.21		
	9	1502	Cooled 45 min in cotton mat cooler and stored at room conditions	77	73	4	28.7	0.004			0.04	0.01	0.60	6.19	0.05 (loss)	0.8 (loss)
	9	1461	Cooled 45 min in cotton mat cooler and stored in burlap curtain cooler	69	94	4	56.3	0.054		0.01	0.06	0.03	0.60	6.49	0.25	4.0
	9	1485	Stored in burlap curtain cooler	69	94	4	54.0	0.050		0.01	0.04	0.02	0.60	6.48	0.24	3.8
8/22/40 to 9/18/40	4	914	Stored at room conditions	74	67	6	22.5						0.60	6.85		
	4	899	Cooled and stored in burlap curtain cooler	67	89	6	51.7	0.05		0.01	0.04	0.02	0.60	7.45	0.60	8.8
	4	871	Cooled and stored in coil cooler	60	75	6	60.4	0.15			0.04	0.11	0.60	7.52	0.67	9.8
	4	884	Cooled and stored in commercial ice cooler	67	69	6	38.6	0.01	0.39	0.005	0.04	0.13	0.60	6.82	0.03 (loss)	0.4 (loss)
7/10/41 to 9/18/41	10	1108	Stored at room conditions	79	58	4	17.6						0.60	9.30		
	10	1113	Cooled and stored in burlap curtain cooler	68	90	4	51.9	0.05		0.01	0.04	0.02	0.60	9.90	0.60	6.5
	10	1114	Cooled and stored in mechanical refrigerator	37	50	4	44.0	0.03			0.04	0.21	0.60	9.63	0.33	3.5
	10	1114	Cooled and stored in commercial ice cooler	64	65	4	33.0	0.01	0.39	0.005	0.04	0.13	0.60	9.09	0.21 (loss)	2.3 (loss)

*Values given in these columns based on following unit costs: Electricity at 3c per kw-hr, ice at 60c per 100 lb, water at 6c per 1000 gal, and labor at 20c per hr. Depreciation based on: Life of coolers at 10 years, cooling season at 16 weeks, and eggs cooled per week at six cases.

**Values given in this column are the values for net gain (or loss) per case by cooling expressed in percentage of net income per case stored at room conditions (no cooling).

miles of a grading station where eggs are purchased under U. S. Standards. This means that the producer can ordinarily have his eggs on the grading bench within four to six hours after they leave the farm. For egg cooling tests reported in this paper, it was necessary to ship eggs a distance of 258 miles requiring two days time. Therefore, studies were conducted to correlate this abnormal shipping period with egg quality and method of cooling. The results are set forth in Table 2.

TABLE 2. EFFECT OF COOLING EGGS PRIOR TO SHIPMENT ON THE QUALITY AFTER SHIPMENT COVERING 258 MILES VIA RAILWAY EXPRESS IN TWO DAYS TIME

Treatment of eggs prior to shipping	Grades before and after shipment	Eggs graded "extras", per cent	Gross selling price per case, dollars	Loss per case in shipment, dollars	Monetary shipping loss per case, per cent*
Stored at room conditions	As graded before shipping	28.3	7.81		
	As graded after shipping	6.1	7.02	0.79	10.1
Cooled and stored in burlap curtain cooler	As graded before shipping	53.4	8.39		
	As graded after shipping	28.7	7.67	0.72	8.6
Cooled and stored in commercial ice cooler	As graded before shipping	53.6	8.39		
	As graded after shipping	19.0	7.49	0.90	10.7
Cooled and stored in coil cooler	As graded before shipping	61.0	8.64		
	As graded after shipping	50.3	8.14	0.50	5.8
Cooled and stored in mechanical refrigerator	As graded before shipping	40.3	7.96		
	As graded after shipping	37.5	7.74	0.22	2.8

*Values given in this column are the values for loss per case in shipment expressed in percentage of the gross selling price per case for the respective treatments as graded in Blacksburg prior to shipment.

Three of the four methods of cooling were effective in decreasing losses in quality during shipment by seven to 57c per case. The rate of loss was less, for the same three methods, than for eggs not cooled. This indicates that as the distance between producer and market increases, at least up to 258 miles requiring two days in transit, the value of cooling increases.

Effect of Shipping Fresh Eggs in Precooled Cases. On twelve occasions fresh eggs from the laying house were packed in cases from various storage conditions and shipped immediately to Washington. Eggs shipped in cases from storage at room conditions graded 45 to 58 per cent "extras", those in cases from the burlap curtain cooler graded 72 to 74 per cent "extras", and those in cases from the mechanical refrigerator graded 56 per cent "extras". Net gains of 20 to 70c per case were obtained by shipping fresh eggs in precooled cases as compared with shipping in cases from room conditions.

Tests disclosed that cases, containing flats and fillers, reached an equilibrium moisture content of 8.7 per cent when stored at room conditions. Seven days were required for cases to reach an equilibrium of 15 per cent in the burlap curtain cooler. Cases stored in the burlap curtain cooler absorbed 0.6 lb of water to be liberated later in providing moist air around eggs in shipment.

Effect of Humidity on Egg Quality. While no tests have been conducted to determine the specific effect of relative humidity on egg quality throughout a reasonable range in temperature, it so happened that an indication was obtained at a temperature of 74 F. Eggs held at a humidity of 48 per cent graded 1.3 per cent "extras"; those held at 67 per cent graded 5.2 per cent "extras"; those held at 74 per cent graded 51.8 per cent "extras", and those held at 82 per cent graded 50.8 per cent "extras". From these observations the critical point of relative humidity between high and low quality eggs is between 65 and 75 per cent.

Relation of Cooling on the Farm and at the Grading Station. A series of egg cooling studies was conducted from August 18 to September 19, 1941, to correlate the value of cooling on the farm and at the grading station. All eggs were held for a period of one week and given the following treatments: (A) Held at room conditions entire week, (B) held at room conditions for one-half week and then moved to grading room, cooled by burlap screen, for rest of week, (C) cooled and stored in burlap curtain cooler for one-half week and held at room conditions rest of week, and (D) cooled and stored in burlap curtain cooler for one-half week and held in grading room, cooled by burlap screen, for rest of week.

The results showed that the ultimate quality of the egg when consumed is more dependent upon cooling at the grading station than cooling on the farm where holding periods are similar to those of the tests. Eggs from treatment A graded 3.7 per cent "extras", those from treatment B graded 7.0 per cent "extras", those from treatment C graded 5.3 per cent "extras", and those from treatment D graded 29.0 per cent "extras", when shipped 258 miles after treatment. Thus it was found that when eggs are cooled immediately after production and held cool for one week, up to within two days of consumption, by cooling both on the farm and at the grading station, their quality when consumed, based on the number of eggs graded "extras", is 7.8 times that of eggs not cooled at any time, 5.5 times that of eggs cooled on the farm only, and 4.1 times that of eggs cooled at the grading station only.

Since eggs are graded and paid for when received at the grading station, a lack of cooling facilities at the grading station will not effect the value of farm cooling of eggs to the producer.

Mold Growth in Evaporative Coolers. All eggs handled during the course of all egg cooling tests were free from mold when graded, with one exception. In 1940 an accidental leak developed in the upper pan of the burlap curtain cooler causing the flats, fillers, and eggs in one case to become water-soaked. Several lots of eggs in this case were quite moldy when graded and the entire shipment was discarded from final analysis of the records. The fact that new cases, flats, and fillers were used for all tests may have had a favorable effect on the lack of mold growth. However, Mallmann and Michael[5] found that new case material is heavily contaminated with molds. They also found that the incidence of molds on new fillers and flats was low but that those present were genera which may cause mold spoilage of eggs. They concluded that the use of new fillers and flats would not appear to eliminate the contamination of eggs.

According to Sarles, Frazier, and McCarter[10] the contents of most fresh eggs are free from microorganisms and will remain so unless contamination enters through the shell. As long as the shell remains dry, penetration by microorganisms is difficult, but high humidity in the sur-

rounding air will allow molds to enter and condensed moisture on the shell surface will permit bacterial invasion.

Condensation of moisture on the egg shell can be largely prevented by cooling and storing eggs at or slightly below the dew-point temperature of the air in which the eggs will be graded, packed, and shipped. Observations during the summer of 1941 showed that the atmospheric dew-point temperature in Virginia during the day when eggs are normally graded, packed, and shipped, ranges between 53 and 57 F in the upland regions and between 63 and 67 F near the seacoast. Therefore, it appears that eggs should not be cooled and stored at temperatures below 50 F in the upland regions and 60 F near the seacoast.

Trouble from mold growth in evaporative egg coolers, of the burlap curtain type, has been reported by others. However, the addition of the small electric fan not only provides a more desirable temperature and humidity in the cooler but insures ample ventilation at all times and a definite filtration of all the air going into the cooler as it passes through the wet curtain. Alp, Ashby, and Card[2] indicate that ample ventilation around the burlap curtain cooler, even without the fan, is the deciding factor in prevention of mold growth. Bacteriologists[10] do not recognize ventilation alone as an agent to the prevention of mold growth, but they definitely recognize filtration as an excellent method of removing microorganisms from a gas or liquid. Most of the microorganisms in air are carried on dust particles which will adhere to a wet or oily surface. On several occasions mold growth was observed on the outside surface of the burlap curtain and was killed by an application of hot water.

Whether or not the added ventilation and filtration principle provided by the electric fan on the burlap curtain cooler prevented mold growth on eggs cooled is not known. From the tests conducted it is reasonable to believe that the losses which might be incurred from the growth of mold on eggs in the burlap curtain cooler will be greatly offset by the added income from cooling eggs in this simple, inexpensive equipment.

SUMMARY

1 There is no significant loss in egg weight, either with or without cooling, during short holding periods of four to six days. Where eggs are sold from the farm semiweekly through a market which considers quantity only, as does the country store, or quantity and weight as many commission merchants do, there can be no financial gain by cooling eggs.

2 Where eggs are sold on a graded basis (U. S. Standards of Quality for Individual Eggs, or an adoption thereof) during hot weather, the producer cannot afford to neglect the cooling of eggs. A consistent gain in net income of one to two cents per dozen will be effected when eggs are cooled by a carefully selected method. This gain will be effected almost independent of fluctuations in egg prices.

3 The value of cooling eggs increases as the length of holding period on the farm increases.

4 The value of cooling eggs on the farm increases as the distance between producer and market increases, at least up to 258 miles requiring two days in transit.

5 Net gains of 20 to 70c per case were obtained by shipping fresh eggs in precooled cases as compared with shipping in cases not precooled. Cases, containing flats and fillers, will absorb 0.6 lb of water while in the burlap curtain cooler seven days.

6 Indications are that with a mean ambient temperature of 74 F, the critical point of ambient relative humidity between high and low quality eggs lies between 65 and 75 per cent.

7 When eggs are cooled immediately after production and held cool for one week, up to within two days of consumption, by cooling both on the farm and at the grading station, their quality when consumed, based on the percentage of eggs graded "extras", is 7.8 times that of eggs not cooled at any time, 5.5 times that of eggs cooled on the farm only, and 4.1 times that of eggs cooled at the grading station only.

8 Since eggs are graded and paid for when received at the grading station, a lack of cooling facilities at the grading station will not effect the value of farm cooling of eggs to the producer.

9 All eggs handled during the course of all egg cooling tests were free from mold when graded, with one exception. This exception was caused by an accidental leak in the burlap curtain cooler and the flats, fillers, and eggs in one case became water-soaked.

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Agricultural Engineering in India

By Mason Vaugh and M. D. Strong
ASSOCIATE A.S.A.E. JUNIOR MEMBER A.S.A.E.

THE FIRST and only agricultural engineering course in southern Asia is being initiated at the Allahabad Agricultural Institute in the heart of India. The Institute is an integral part of the Allahabad Christian College, which is sponsored by the American Presbyterian Mission. It was founded in 1910 in the belief that the improvement of Indian agriculture is fundamental to all material and spiritual progress.

Following the purchase in 1911 of 275 acres of land, considerable progress has been made in the improvement of the land and in erecting the necessary buildings. Additional land has been purchased, bringing the total area up to about 600 acres. Work bullocks are used to carry on farm operations, and a herd of 250 milk cows is maintained on the farm, with the necessary equipment and barns for their care. Students have come from all parts of India, as well as from Persia, Mesopotamia, Malaya, Ceylon, and the Fiji Islands.

The Institute is supported largely by donations and government grants. Its credits are recognized by the government. At the present time a bachelor of science degree in agriculture is given, with a major in dairy, horticulture, and agronomy. The students are taught agricultural engineering subjects in all four years. The subjects include farm shop, irrigation and drainage, farm structures, surveying, and farm motors. At present about 150 students are enrolled.

The agricultural engineering department, besides its teaching schedule, devotes a large part of its time to the operation of a shop in which a variety of farm implements and dairy equipment is designed and manufactured for sale, as well as for use on the farm. During the last twenty months approximately 1,270 improved plows and cultivators were manufactured and sold. All classroom buildings, farm buildings, and staff quarters are constructed by the agricultural engineering building crew. A number of research projects on the design of implements especially suited to Indian conditions are also in progress.

The plight of the Indian farmer is a difficult one. India's 400 million people, 90 per cent of whom live in 700 thousand small villages, live in an area one-half the size of the United States and Alaska combined. Much of the land is untillable because of mountains or deserts. The average farm of the United Provinces, where the Institute is located, is approximately five acres, and is generally divided into a number of small plots scattered about within a radius of a mile or so of the village where the farmer lives.

Authors: Agricultural engineers, Allahabad Agricultural Institute.

The farmer's one-story house has walls of solid mud. The roof is a bamboo framework over which is laid small tile. There are generally not more than two rooms approximately ten by twelve feet, with a thatch-covered verandah which serves as a shelter for the bullocks, a cow, or a goat. The house generally costs about $50. The total cost of his farming equipment ordinarily does not exceed $20, the largest item being bullocks, which are the chief source of power, other than man power, in India. In some sections the camel is used a great deal, but not in general.

The farmer's chief implement is his wooden plow, which does not turn a furrow but merely makes a V-shaped scratch. It is generally necessary to go over the land three or four times before planting the summer fodder crop, and eight or ten times for wheat and barley. This means the operator must walk 50 miles or more in plowing one acre for his fodder and 100 miles or more in planting his wheat. The job of the agricultural engineer is to improve implements that can be purchased by this man, whose average income ranges between $20 and $50 per year, and whose chief source of power is two light bullocks.

There is a growing demand for the services of agricultural engineers in India. At present the agricultural departments of the larger provinces have a department of agricultural engineering, but in only one province has the post of agricultural engineer been filled by a man with a degree in agricultural engineering. In a second province the post of assistant agricultural engineer is filled by a man with an agricultural engineering degree. The former is known to many of the members of the American Society of Agricultural Engineers. He is P. J. Patel, who took his B.Sc. and M.Sc. degrees at Iowa State College. Possibly two men with specific training in agricultural engineering are employed by machinery companies in India, while the Institute has two men on its staff who have degrees in agricultural engineering. With the steady increase in the introduction of improved farm implements,

Left: This view shows how plow beams are sawed from logs in workshop of the Allahabad Agricultural Institute. Right: This farmer of India is plowing his field with a village-made plow

there will be a growing demand from industry for men trained in this line. The agricultural engineering course at the Institute is an attempt to fill the demand for these men in India.

In the Indian educational system, college work is divided into two parts. The first two years, which are similar to junior college in America, are completed. Then the student decides whether or not he wishes to go on, and in what subject he will major. The agricultural engineering course will take its students from those who have passed their first two years in agriculture. The list of subjects to be taught, not unlike that of the average agricultural engineering course in America, is as follows: Advanced shop work, engineering drawing, structural design, agricultural structures, materials of construction, strength of materials, mechanics and statics, agricultural machinery, principles of electrical machinery, farm management, soil and water conservation (including surveying), and machine design.

Engineering Contribution to War Program in Agriculture

By Harry L. Brown

IN THE prosecution of an all-out war program, agriculture will necessarily play an important part. In September last the Secretary of Agriculture set goals for the production of certain farm products for which the need was accelerated by the defense program. Now that need is greater because we are actually at war. Then it was a problem of increasing the production of these vital crops and livestock products. Now it is not a question of *whether* it will be done, but *how* it can best be done. In all this effort electricity and farm machinery will play an important role. With much of the man power of the farm being diverted to the armed forces and the need for greater production on the farm, the farm labor situation becomes doubly acute. Both electricity and farm machinery, therefore, must be used to the greatest extent practicable.

Get the increased production we will, but we must not get it at the expense of the soil. It is true we would be justified in calling on some of the soil reserve to meet a national emergency. Even so, it would be folly to go too far in that direction. We did so in the first World War by plowing up much land which never should have been plowed. The challenge to the American farmer is to meet this war need without the sacrifice of the soil resource. Sound planning will enable him to meet the challenge.

We can agree, I am sure, that the efforts in recent years towards safer use of the land constitute a godsend now. Through greater use of soil-building practices the land has been made ready for this emergency, even though we were not planning for war when that program was put into operation. The increased production needed now will be stepped up on these improved lands through higher yields per acre. We must avoid cultivation of such lands as will mount production costs through low yields and at the same time depreciate the lands by such unsound use. Whether the war is of relatively short duration or prolonged, it behooves the American farmer to conserve his and one of the nation's chief resources, the soil.

Let's go back to the farm labor situation and consider further what electric energy may do to help. One of the first considerations is of course the cost of electric energy. It is interesting to note at this point that for the period 1910-23 the average cost of this energy on farms was 18c per kw-hr. For the period 1923-35, this cost was lowered to 9c per kw-hr. The average cost over the period 1935-40 was 4½c per kw-hr. The philosophy expounded and practiced by the TVA and REA has been, and is, to get profits from the sale of electric energy through volume rather than through margin. Happily public utilities are subscribing to this philosophy. The progressive lowering of the cost of electricity as indicated above is a result.

Though electricity on the farm is in one sense a luxury, if wisely used it is an obedient and faithful servant. It can more than pay its way in the saving of labor alone. A five-dollar monthly electric bill doesn't have to save much labor at present costs to be in the black.

The health of the people on the farm is important, both in times of peace and in times of war. Electricity makes a definite contribution in this direction. Ever-ready refrigeration saves food and makes it possible for farm people to have a more adequate and varied diet throughout the seasons of the year.

Farm machinery if adapted to the particular farm is the most practicable means of meeting the labor shortage. The larger farms are already largely mechanized. It seems to me that the challenge to the farm machinery people today is to adapt machinery to small and medium-sized farms.

In addition to the adaptation of farm machinery, thought should be given to its cooperative use. Everybody who is in position to lend encouragement to cooperative action on the part of farmers in the use of farm machinery, should do so.

Unquestionably many farmers in adjusting to a more mechanized agriculture will need additional financing. For all farmers who have a basis of credit, loans at reasonable rates of interest are now available. Legally organized and soundly operated farmers' cooperatives can also secure ample financial assistance at low interest rates. Fortunately, therefore, farmers need not be handicapped in adjusting to the new needs and the new situations because of a lack of credit.

Agricultural engineers have in their hands today a wonderful opportunity to serve the farmers and the nation. With that opportunity there rests on your shoulders a corresponding responsibility. Let me urge that through the regular education channels you bend every possible effort that farmers make practical applications of the things which have been learned through technical research in engineering. In other words, you should consider it just as much a service to keep a farmer from buying unadapted farm machinery as to induce him to purchase machinery that can and will do the job satisfactorily. I am sure you do not want any "fence-corner monuments" represented by unadapted, expensive farm machinery which has been pushed aside.

Let me urge also that you think beyond the emergency in adapting electricity and machinery to war needs. Instead of permitting the emergency situation to lead us astray, let's take advantage of it to the end that we will have made greater strides in the use of electricity and machinery on the farm because of the war than would have otherwise been the case.

Paper presented February 6, 1942, at a meeting of the Southern Section of the American Society of Agricultural Engineers at Memphis, Tenn. Author: General agent, Farm Credit Administration of Columbia (S.C.); formerly assistant secretary of agriculture, U.S.D.A.

Performance of Domestic Frozen Food Cabinets

By John E. Nicholas

MEMBER A.S.A.E.

THE development of domestic type frozen food cabinets has followed very closely the rapid growth of frozen food locker storage plants. Their public acceptance is being studied by all agencies interested in food preservation.

Several domestic type units have been under observation by the author, some for over a year, and certain pertinent data have been obtained under approximately normal "home use" practices.

Four families were assigned the use of three units. The housewives prepared the vegetables to be stored according to standard practices, whenever their home garden supply warranted packaging. The quantities packaged at any one time varied during the season. When peas were available, two housewives working together prepared from six to ten 1-lb packages at a time. In packaging string beans a maximum of twenty packages were put up at one time. During the peach season, one-half bushel was considered a reasonable share per housewife, because speed and greater care in handling the fruit was necessary.

Berries were put up in syrup and in the dry state. Huckleberries provided an interesting variation. These were packaged dry in cellophane wrapping. Some red raspberries were also put up in a similar manner. All meat, fruit, and vegetable packages were labeled with the owner's name, the contents, and the date put up. The individual housewives used the frozen products whenever their family menus called for the product frozen. All of the frozen food met with their approval and none spoiled. There was no waste during the entire ten months of this test, after the foods were frozen. Some of the foods, cauliflower for instance, were considered of better quality after being frozen than before.

Following is a list of the foods frozen, in connection with which the word "dry" implies that neither syrup nor weak brine was used in the packaging of the product: Lima beans (dry), string beans (dry), peas (dry), raspberries (cultivated and wild), melons (dry), honeydew (dry), strawberries (in sugar and in syrup), peaches (in sugar syrup), mint (leaves), smoked sausages, beef, huckleberries, cauliflower, and corn off the cob.

Article prepared especially for AGRICULTURAL ENGINEERING. Authorized for publication on May 11, 1942, as Paper No. 1100 in the Journal Series of the Pennsylvania Agricultural Experiment Station. Author: Professor of agricultural engineering, The Pennsylvania State College.

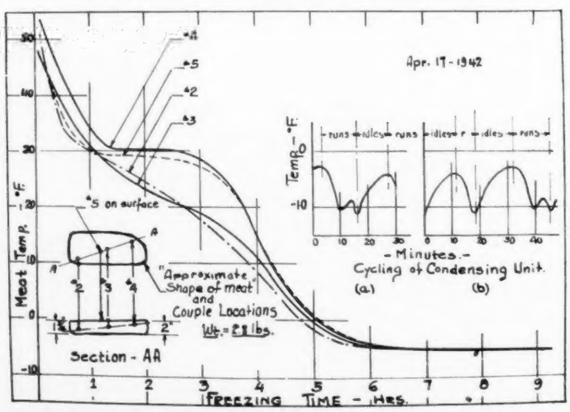


Fig. 1 Sharp freezing of a piece of steak in a domestic-type frozen food cabinet

Rate of Freezing Meat. The freezing of products when done by air is known as sharp freezing as differentiated from quick freezing. In the latter case the freezing process is done by direct contact with liquid brines or plates through which the refrigerant is circulated. In sharp freezing the product takes a longer interval in passing through the zone of maximum crystal formation. The rate of freezing of a piece of meat in a sharp freezer depends on the shape, weight, and compactness of wrapping, on the type of wrapper, and on the location of the package in the freezer, as well as on the amount of other products freezing simultaneously.

PHYSICAL DATA AND COST OF OPERATION OF THE THREE DOMESTIC TYPE FROZEN FOOD CABINETS

Cooler No.	Food compartments, cu ft Freezing	Storage	Total	Motor hp	Kwh per month	Temperature (deg F) of Freezer (max)	Storage
1	3	same	3	1/5	56.0	–10	same
2	1.5	4.5	6	1/4	65.0	–10	0
3	5	10	6	1/3	123.0	–10	0

Experimental determinations were made on different shapes, cuts, and weights of meat. Fig. 1 shows the time-temperature curves obtained by four couples located "on" and "in" a piece of steak weighing 2.8 lb; the approximate shape and a cross section on line A-A is shown in the figure. The piece of meat was placed in the freezer with one flat surface in contact with the plate, the rest of the meat being exposed to the air. The entire piece did not freeze simultaneously; a portion of it required about 2 hr to pass through the zone of crystal formation. At the end of the sixth hour, the whole of the steak was very nearly uniformly frozen.

The plate temperature variation during cycling for two complete cycles is indicated; the range was found to be between –3 and –11 F (degrees Fahrenheit).

Tests have shown that a 5-lb roast has an approximate 6-hr zone of crystal formation, reaching nearly uniform temperature in 15 to 16 hr under similar conditions of freezing and cycling.

A 5-lb roast removed from the freezer and placed in an average 38 F temperature compartment of a domestic refrigerator required nearly 10 hr to reach the average temperature of 28 F. After 30 additional hours parts of the meat attained a temperature of 31.5 F with the largest portion of it below 30 F.

Meats carefully wrapped in moistureproof cellophane did not show any loss in weight during freezing.

SUMMARY

1 The cost of operation for 3, 6, and 15-cu ft domestic type of frozen food cabinets was found to be 56, 65, and 123 kwh per month, respectively.

2 The opinion of the housewives on all of the food frozen was that it was highly satisfactory.

3 For the period of this study (10 months), all foods frozen were usable. There was no loss.

4 Frozen cauliflower was considered preferable to fresh cauliflower.

5 Studies will continue in which different wrapping materials and variations in vitamins will be observed.

NEWS

Personals of A.S.A.E. Members

E. N. Bates, senior marketing specialist, agricultural marketing service, U. S. Department of Agriculture, is author of Circular No. 630 recently issued by the Department, entitled "Improved Bates Laboratory Aspirator."

F. L. Browne, senior chemist, Forest Products Laboratory, U. S. Department of Agriculture, is author of technical bulletin No. 804, recently issued by the Department, entitled "Classification of House and Barn Paint," which contains recommendations of the U.S.D.A.

George A. Crabb, Jr., was recently appointed an instructor in the department of agricultural engineering, Virginia Polytechnic Institute. He was previously an assistant engineering aide with the U. S. Soil Conservation Service.

O. C. French, lecturer in agricultural engineering and assistant agricultural engineer in the agricultural experiment station, University of California, is author of Bulletin 666, entitled "Spraying Equipment for Pest Control," just issued by the California station.

Loring O. Hanson, formerly farm representative for the Portland Cement Association in Wisconsin, is at present employed as associate civil engineer with the Engineer Corps, U. S. War Department, and is located at Buffalo.

William F. Heesch is now chief, production control unit, ordnance department, U. S. War Department. He was formerly assistant sales manager, Ingersol Steel and Disc Division, Borg-Warner Corp.

P. R. Hoff, extension agricultural engineer, Cornell University, is one of the authors of Bulletin 366, entitled "Brooding Chicks under Electric Hovers," published by that institution originally in 1937 and recently revised.

B. A. Jennings, professor of agricultural engineering, Cornell University, is author of Bulletin 381, entitled "Plow Adjustment," issued originally by that institution in 1937 and recently revised.

Mack M. Jones, professor, and *Lloyd E. Hightower,* instructor in agricultural engineering, University of Missouri, are joint authors of Circular 232, entitled "Plow Adjustment and Operation," and Circular 449, entitled "Mower Repair and Adjustment," recently issued by the University.

C. F. Kelly is one of the authors of Circular No. 637, entitled "Wheat Storage in Experimental Farm-Type Bins," just issued by the U. S. Department of Agriculture. Copies of the bulletin may be obtained from the Superintendent of Documents in Washington at 30 cents per copy.

R. L. Perry, associate professor of agricultural engineering, and associate agricultural engineer in the agricultural experiment station, University of California, is one of the authors of Bulletin 664, entitled "Handling and Shipping Tests with New Potatoes from Kern County, Calif.," recently issued by California Station.

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Albert M. Best, New Holland Machine Co., New Holland, Pa. (Mail) 217 W. Main St.

H. T. Hargrave, assistant agricultural engineer, Dominion Experimental Station, Swift Current, Sask., Canada.

Elmer B. Hudspeth, Jr., RR No. 1, Caddo, Tex.

William D. James, president and general manager, James Mfg. Co., 104 W. Milwaukee Ave., Fort Atkinson, Wis.

Herman L. Mowls, junior soil surveyor, Soil Conservation Service, USDA. (Mail) P. O. Box 84, East Canton, Ohio.

John W. Probst, Jr., 2nd Lt., Co. E, 31st Engr. Reg., U. S. Army. (Mail) Boydton, Va.

Anthony E. Theisen, private USA. (Mail) Co. D. 82nd Inf. Trng. Bn., Bks. 3116, Camp Roberts, Calif.

Odin Thomas, personnel director, Harry Ferguson, Inc., Dearborn, Mich. (Mail) 24130 Rockford Drive.

Monroe W. Treiman, general farming, P. O. Box 274, Brooksville, Fla.

TRANSFER OF GRADE

Ernest H. Kidder, assistant hydraulic engineer, research div., Soil Conservation Service, USDA. (Mail) 402 W. Oregon St., Urbana, Ill. (Junior Member to Member)

Agricultural Engineering Digest

A review of current literature by R. W. TRULLINGER, assistant chief, Office of Experiment Stations, U. S. Department of Agriculture. Copies of publications reviewed may be procured only from the publishers at the addresses indicated.

A FLOW METHOD FOR THE DETERMINATION OF THE EFFECTS OF SOLUBLE CHEMICALS ON CONCRETE, *D. G. Miller, C. F. Rogers,* and *P. W. Manson.* (Minn. Ag. Exp. Sta. coop. U.S.D.A. et al) Amer. Soc. Testing Matls. (Philadelphia), Proc. 39 (1939); abs. in Rpt. (1940) of Minn. Ag. Exp. Sta., St. Paul. Weak solutions of acetic acid and lactic acid were allowed to flow at the rate of 2 l in 24 hr over channels 1.5 in wide on flat slabs of concrete and mortar set up at an angle of 17 deg from the vertical. The channels were formed either by paraffin dikes, permitting the acids to flow over on area 1.5 by 14 in, or by casting bars with shallow channels 1.5 by 14 in. Each channel was brushed with a flat steel brush, and the loosened material was filtered off, dried, and weighed.

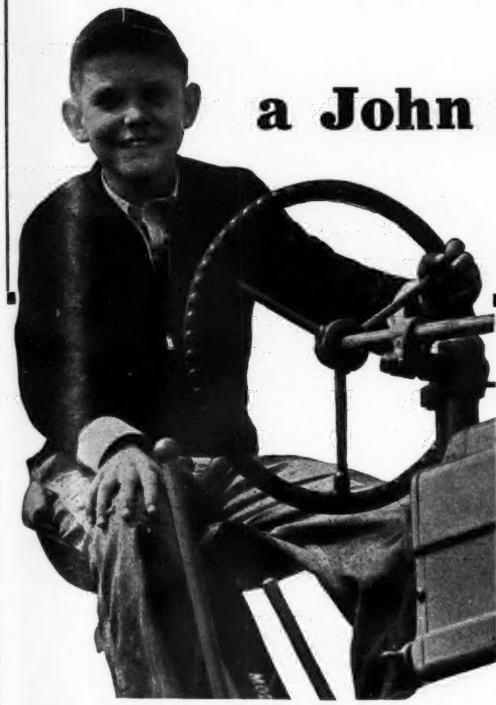
Concrete with a modulus of rupture from 800 lb per sq in upward displayed resistance to corrosion of weak acids three times that of concrete with a modulus of rupture of 500 lb per sq in under the conditions of exposure used in these tests. Mortar made of the least resistant of nine standard portland cements yielded a quantity of loosened material 1.6 times that released by mortar made of the most resistant of these nine cements. Within the range of characteristics of the specimens used in the tests, the acid consumption was surprisingly uniform. Similar work with acid solutions simulating the acidity of silage juices has been reported by the same authors.

TEMPERATURES OF WHEAT IN EXPERIMENTAL FARM TYPE STORAGES, *C. F. Kelly.* (Coop. N. D., Kans., Ill., and Md. Ag. Exp. Stas.) U. S. D. A. (Washington). Cir. 587 (1941). A detailed study of the temperature of wheat stored in structures of various sizes (from 20 to 1,000 bu) and type at Fargo, N. D.; Hays, Kans.; Urbana, Ill.; and College Park, Md., is described, and the monthly average wheat temperatures found in 161 bins at the bin centers and 6 in from the north and south walls are recorded.

Atmospheric conditions and bin size and type were found to be the most important factors influencing the temperature of dry wheat. The periods of average air temperatures above 70 F at Hays were 2.5 times as long, and at College Park and Urbana about twice as long, as at Fargo. These temperature differences were reflected in the wheat temperatures. The size of unventilated bins of similar construction in the same locality was found to determine the lag of the temperature of dry wheat behind the air temperature. The insulation value of a bin wall was found to be an important factor in determining the temperature of the outside layers of wheat but not that of the interior. Shading bins proved effective in preventing outside heat from raising the wheat temperature. Bin ventilation was the most effective method of dissipating heat generated in the wheat mass. Insulation of a storage structure may be an advantage in preventing dry wheat from reaching high temperatures, but if the temperatures finally reached are such as to start excessive internal production of heat, insulation is a decided disadvantage. Storage in underground bins is advantageous in maintaining a low temperature in wheat placed in the bin at a low initial temperature or when the wheat moisture content is low enough to make the generation of large amounts of heat improbable. Wheat placed in underground storages at a high initial temperature, however, may deteriorate before cooling to safe temperatures.

AGRICULTURAL ENGINEERING INVESTIGATIONS (ALABAMA). Alabama Ag. Exp. Sta. (Auburn). Rpt. (1939). F. A. Kummer reports briefly upon the dynamic properties of soils as applied to the elements of implement design, including comparative tests with different plow shapes and materials.

IRRIGATION PROBLEMS IN CITRUS ORCHARDS, *C. A. Taylor.* U. S. D. A. (Washington). Farmers' Bul. 1876 (1941). This publication reports a study of irrigation practices and yields in orchards in Los Angeles and San Bernardino Counties, Calif., and recommends certain improvements in methods of cultivation that will make for better use of water. Conditions being similar in other areas, it is believed that many orchardists will find use for the improvements in irrigation practices that are suggested. Attention is directed to the water and soil losses and irregular water distribution resulting from the use of deep, narrow irrigation furrows and to the possibility of avoiding these troubles by means of wide, shallow furrows. The advantages of cross-blocking of furrows are noted, and desirable furrow layouts are shown. For erosible hillsides lowhead sprinklers are suggested, together with alternate-middle irrigation. *(Continued on page 238)*



Agricultural Engineering Digest

(Continued from page 236)

A COMBINATION SUSPENDED-LOAD SAMPLER AND VELOCITY METER FOR SMALL STREAMS, *A. G. Anderson.* U. S. D. A. (Washington), Cir. 599, (1941). The author describes a combination suspended-load sampler and velocity meter which consists essentially of two tubes fitted through a rubber stopper and inserted into an ordinary pint milk bottle. Details of the instrument, which is unusually simple in construction and comparatively easy to use, are shown in drawings and photographs. Water and sediment enter through a lower tube, and the air in the bottle is forced out through an upper tube, which is bent backward over the bottle in the direction of the stream flow. Both tubes are bent slightly upward inside of the bottle to increase the volume of sediment-laden water that may be trapped and to reduce to a minimum the constant static head that exists between the inside end of the water tube and the outside end of the air tube. A small static head is desirable to overcome the effect of waterdrops that may collect in the air tube when the sampler is being lowered in streams of low velocity and to counteract to some extent entrance losses. The tube, through which the water enters, projects forward from the stopper a sufficient distance to minimize the effect of the container upon the flow near the entrance of the tube, but not so far as to alter appreciably the compactness of the sampler. Means for attaching a number of the sampler bottles to a support of 1½x3/16-in strap iron are also shown, and the calibration for velocity determination, the depth correction, and the operation of the device are discussed, together with the hydraulics of such a combination sampler and meter as worked out theoretically and by means of experiments in a small circulating flume operated at known suspended load and current velocity. The construction of the flume is shown in plan and section drawings.

COMBINE HARVESTERS IN MISSOURI, *M. M. Jones and R. P. Beasley.* Missouri Ag. Exp. Sta. (Columbia) Bul. 426 (1941). Surveys following the harvests of 1937, 1938, and 1939 showed that a large majority of the 182 owners found combines to be economical and satisfactory in operation. The average acreage of grain cut per day varied from 7.6 acres for 40-in combines and 13.8 acres for 5-ft machines to 25.3 acres for 12-ft machines. The maximum acreage of wheat and oats that a farmer should expect to cut per year was estimated by the owners to be 125 acres for 40-in machines, 236 for 5-ft machines, and up to 388 acres for the 12-ft sizes. Custom work accounted for about one-third to one-half of the total work done and proved satisfactory in general both to combine owners and to farmers hiring the work done. The average time lost per season on account of breakdowns was only 6 hr. Repair costs varied from 2 to 5.5c per acre.

The cost of combining was affected most by the total acreages harvested per year. Records of 53 5-ft machines showed from 78c per acre for between 401 and 450 acres per year to $2.19 per acre for less than 100 acres per year. The average cost for the 5-ft machines was $1.24 per acre, and the average acreage harvested per season was 238. Tables of estimated costs of combining for various sizes of machines harvesting various acreages per year are given. Comparisons are also made with estimated costs of the binder-thresher method of harvesting. The cost of combining with 40-in combines pulled by one-plow tractors under average conditions is estimated to vary from $1.64 to $3.03 per acre, with 5-ft combines pulled by two-plow tractors from $1.14 to $3.90 per acre, and with 10-ft combines from $1.22 to $3.61. The cost with the binder-thresher method was from $2.98 to $3.75 per acre.

A TEST CUP SOLUTION RACK, *W. H. Sheldon and J. M. Jensen.* Michigan Ag. Exp. Sta. (East Lansing) Quart. Bul. 23 (1941), No. 4. This device, of which a fully dimensioned working drawing and photograph are reproduced with the article, holds the cups and tubing so that they may remain filled with the 0.4 per cent lye solution recommended for cleaning and disinfecting. The rack includes also a shelf for a supply bottle of the lye solution. It is of wood and is easily and cheaply made.

AGRICULTURAL ENGINEERING INVESTIGATIONS (TENNESSEE). Tennessee Ag. Exp. Sta. (Knoxville), Rpt. (1939). This report notes a run-off sampling and measuring device, described by A. L. Kennedy and K. B. Sanders; and equipment for handling legumes, by M. A. Sharp.

SAVE THE SOIL WITH CONTOUR FARMING AND TERRACING, *E. W. Lehmann and R. C. Hay.* Univ. of Ill. Col. of Agr. (Urbana). Ext. Cir. 513 (1941). This circular emphasizes the well-known advantages of contour farming and terracing and presents practical information on systems of contour plowing and planting, planning contour and terrace systems, locating and marking the lines, grass waterways and terrace outlets, constructing the terraces, maintaining a terrace system, and cost of terracing. An appendix deals with the use and care of the level.

EMPLOYMENT BULLETIN

The American Society of Agricultural Engineers conducts an employment service especially for the benefit of its members. Only Society members in good standing may insert notices under "Positions Wanted," or apply for positions under "Positions Open." Both non-members and members seeking to fill positions, for which ASAE members are qualified, are privileged to insert notices under "Positions Open," and to be referred to members listed under "Positions Wanted." Any notice in this bulletin will be inserted once and will thereafter be discontinued, unless additional insertions are requested. There is no charge for notices published in this bulletin. Requests for insertions should be addressed to ASAE, St. Joseph, Michigan.

POSITIONS OPEN

AGRICULTURAL ENGINEER wanted to fill position of assistant in full-time research work primarily in soil erosion control and farm machinery by a southern agricultural experiment station. The work will be on a 12-month basis, with 30-day vacation. Salary according to qualifications. While position is to fill vacancy due to war service, it is expected that it will become permanent. PO-138

AGRICULTURAL ENGINEER wanted to fill position open in northeastern university due to absence of staff member in military service. Work involves approximately half extension and half resident instruction. Major concentration in farm structures and soil and water conservation. Salary up to $3000 for qualified person. PO-137

SALES ENGINEER wanted. Excellent opportunity offered for young agricultural engineer with good background in farm building construction. Work involves direct sales of building material to dealers, architects, contractors. Earnings equivalent of salary of $3000.00 a year or more and unusual possibilities for advancement with rapidly expanding organization. Applicants should indicate marital status, number of dependents, selective service classification, earnings expected. PO-135

CIVILIAN ENGINEERS. Due to expansion of activities, the Signal Corps of the U. S. Army is in need of civilian engineers who have specialized in engineering materials, metallurgy, or related fields. Interested engineers should apply in writing giving a full statement of their education and experience. Those selected will, on appointment, be given Civil Service ratings of P-2 or P-3 ($2600 or $3200 per annum) depending on their experience, and will be assigned to the Office of the Chief Signal Officer, Washington, D. C.

POSITIONS WANTED

AGRICULTURAL ENGINEER with bachelor of science degree in agricultural engineering from middle-western university, eight years' experience in conservation and development of natural resources while employed by Departments of Agriculture and of the Interior, farm background and two years' experience as farm manager, wants opportunity to develop and test what he considers new ideas in machinery, buildings, and conservation. Married. Age 34. PW-349

AGRICULTURAL ENGINEER with B. S. degree in agricultural engineering from Iowa State College. Has four years' experience as engineer with the Soil Conservation Service and five years' experience as state agricultural conservation engineer for the Agricultural Adjustment Administration. Experienced both in engineering and administration. Thirty-two years of age, married, and have family. References upon request. PW-348

AGRICULTURAL ENGINEER with B. S. degree in engineering and M. S. degree in agricultural engineering. Experienced in college teaching, experiment station, and extension work; also factory and construction work. Especially qualified for college agricultural engineering, manufacturing, defense, construction, or trade extension work. Age above draft. PW-346

AGRICULTURAL ENGINEER with B.S. degree from midwestern college (1938) and M.S. degree from southern college (1940), desires employment with the Soil Conservation Service, in a defense industry, or in other engineering work. Has 1½ years' experience as engineer with the U. S. Soil Conservation Service in the South and in the Pacific Northwest. Familiar with agriculture in most parts of the United States. Civil Service rating as junior engineer. Eligible for reappointment. Age 35. Married. PW-345

AGRICULTURAL ENGINEER desires employment offering larger opportunity. Ten years' experience in the electric utility industry and two years' experience as an assistant extension agricultural engineer. Good farm background. Particularly qualified to handle all phases of rural electrification, pump irrigation, and farm machinery. Capable of planning and conducting educational or promotional activities. Holds a state professional engineering certificate. Thirty-six years of age. Married. References on request. PW-344